	Collection Type:	OIL SHALE TRACT REPORTS
4.	Copy:	2 BLM Library
	Call Number:	TN859 .C64 C3752 1984
	Status:	On the Shelf
	Volume:	2
	Item ID:	88020205
	Collection Type:	OIL SHALE TRACT REPORTS
5.	Copy:	3 BLM Library
	Call Number:	TN859 .C64 C3752 1984
Hold	Status:	Checked Out
	Volume:	1
	Item ID:	88057352
	Due Date:	1/16/2012
	Collection Type:	OIL SHALE TRACT REPORTS
6.	Copy:	3 BLM Library
	Call Number:	TN859 .C64 C3752 1984
Hold	Status:	Checked Out
	Volume:	2
	Item ID:	88057353
	Due Date:	1/16/2012
	Collection Type:	OIL SHALE TRACT REPORTS

Page: [1 of 1]


1
2
3
4
5
6
7
A
B
C
D
230
231
E. 1,232,000
233
234
235
E. 1,236,000
237
238
239
E. 1,240,000
241
242
243
E. 1,244,000
246
247
E. 1,248,000
249
188
187
186
185
184,000
183
182
181
FIGURE 4-3
FIGURE 4-5
FIGURE 4-2
FIGURE 4-4
FOLD

THESE DRAWINGS WERE COMPILED USING AERIAL METHODS AND PHOTOGRAPHY TAKEN ON AUG. 27, 1980.

GROUND SURVEY CONTROL BY CONSTRUCTION SURVEYS, INC. RIFLE, COLORADO.

PHOTOGRAMMETRIC SERVICES BY SCHARF AND ASSOCIATES, DENVER, COLORADO.

REFERENCE DWG. No.	DRAWINGS DESCRIPTION
AD-0018	AREA MASTER INDEX

REV.	DESCRIPTION	DRAWN	DATE	CHK'D.	APPR.	APPROVALS
						DRAWN DATE
						CHECKED DATE
						APPROVED ENG.
						APPROVED
1	GRID & FIGURE Areas Outlined	VS	4/1/82			APPROVED

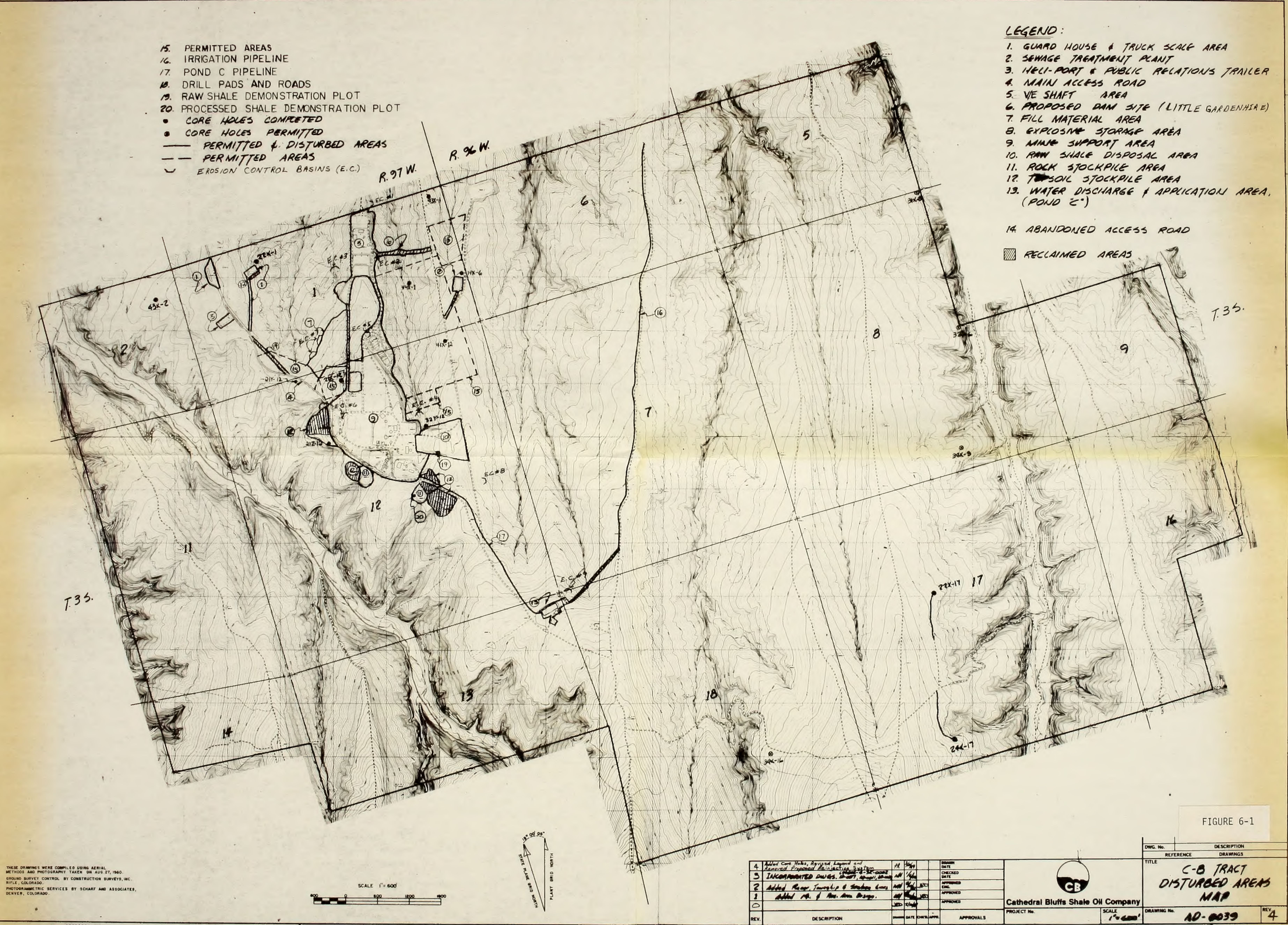
Cathedral Bluffs Shale Oil Company

TITLE

FIGURE 4-1
C-b TRACT
TOPOGRAPHIC MAP

PROJECT No. ESF-13.3 | SCALE 1" = 600' | DRAWING No. AD-0017 | REV. P

FOLD



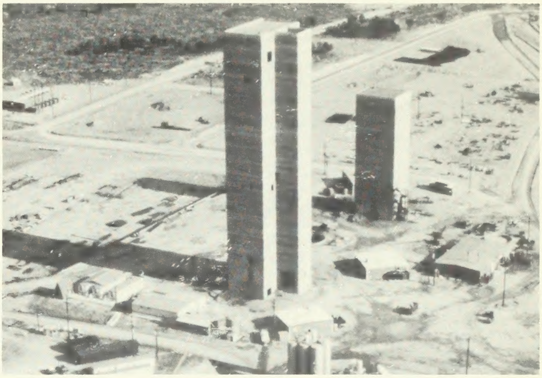
15. PERMITTED AREAS
16. IRRIGATION PIPELINE
17. POND C PIPELINE
18. DRILL PADS AND ROADS
19. RAW SHALE DEMONSTRATION PLOT
20. PROCESSED SHALE DEMONSTRATION PLOT
• CORE HOLES COMPLETED
• CORE HOLES PERMITTED
PERMITTED & DISTURBED AREAS
PERMITTED AREAS
EROSION CONTROL BASINS (E.C.)
LEGEND:
1. GUARD HOUSE & TRUCK SCALE AREA
2. SEWAGE TREATMENT PLANT
3. HELI-PORT & PUBLIC RELATIONS TRAILER
4. MAIN ACCESS ROAD
5. V/E SHAFT AREA
6. PROPOSED DAM SITE (LITTLE GARDENHIRE)
7. FILL MATERIAL AREA
8. EXPLOSIVE STORAGE AREA
9. MINE SUPPORT AREA
10. RAW SHALE DISPOSAL AREA
11. ROCK STOCKPILE AREA
12. TOPSOIL STOCKPILE AREA
13. WATER DISCHARGE & APPLICATION AREA, (POND "C")
14. ABANDONED ACCESS ROAD
RECLAIMED AREAS
R. 97 W.
R. 96 W.
T. 3 S.
T. 3 S.
SCALE 1" = 600'
STATE PLANE GRID NORTH
PLANT GRID NORTH
THESE DRAWINGS WERE COMPILED USING AERIAL METHODS AND PHOTOGRAPHY TAKEN ON AUG. 27, 1980.
GROUND SURVEY CONTROL BY CONSTRUCTION SURVEYS, INC. RIFLE, COLORADO.
PHOTOGRAMMETRIC SERVICES BY SCHARF AND ASSOCIATES, DENVER, COLORADO.
4 Added Core Holes, Revised Legend and Removed Proposed Reinjection System
3 INCORPORATED DWGS.
2 Added Range, Township & Section Lines
1 Added M. & Res. Area Drawings.
REV. DESCRIPTION DATE CHK'D. APPR. APPROVALS
Cathedral Bluffs Shale Oil Company
PROJECT No.
SCALE 1" = 600'
TITLE C-B TRACT DISTURBED AREAS MAP
DRAWING No. AD-0039
REV. 4

FIGURE 6-1

6.0 Environmental Effects & Control Plans (from 6.7)
7.0 Socioeconomic & Transportation
8.0 Development Monitoring Plan
9.0 Document Control

Volume 2 of 2

DRAFT



Revised Detailed Development Plan

1984

Cathedral Bluffs Shale Oil Company

A Colorado Partnership of Occidental Oil Shale, Inc. and Tenneco Shale Oil Company

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

6.7

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.7 Solid Waste

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.7 Solid Waste

6.7.1 Activities Generating Wastes

Normal production activities for the Project will produce both solid wastes and sludges. The retorting and upgrading processes will generate retorted shale as the major waste plus other minor solid waste streams. Like any project or municipality, office and construction trash and sewage will be also generated.

6.7.2 Regulations and Permits

The C-b Lease provides guidelines and the State of Colorado provides regulatory requirements for disposal of mine waste, retorted shale wastes, and other wastes. Also, the Colorado Mined Land Reclamation Board will have regulatory control over the surface disposal and reclamation of shale produced from mining and processing. Wastes which are classified as hazardous will be handled per requirements of the Resource Conservation and Recovery Act (RCRA) and applicable Colorado Department of Health regulations.

Unishale B retorted shale has been tested (CB, 1982a) and does not exhibit any of the characteristics of hazardous waste under the RCRA regulations. None of the major waste streams are hazardous; therefore only compliance with state regulations is required.

6.7.3 Waste Inventory and Management Plan

6.7.3.1 Sludges

Sludges will be produced by several components of the process; the oil water clarifer, the sanitary sewage treatment facility, the mine water treatment facility, and the shale oil/water separation unit. These sludges will be dewatered as necessary and the nonhazardous wastes conveyed to the retorted shale pile for disposal. If any sludges are determined to be hazardous wastes they will be managed in accordance with applicable RCRA requirements. Sewage sludge may be utilized as a soil amendment for retorted shale revegetation.

6.7 Solid Waste

6.7.3.2 Raw Shale

The facilities for handling and storing run of mine (ROM) shale are discussed in Section 3.4. During the pre-retorting construction period, ROM shale will be accumulated in a storage area at the head of East No Name Gulch. The storage area will contain approximately 3 million tons, and will have a surface area of approximately 33 acres at its maximum size. Dust from the storage piles will be controlled by water sprinkling and/or dust palliatives. Transfer between storage pile and the stacker terminal will be by trucks. Management practices for the control of effluent drainage will be similar to those described for retorted shale in Section 6.8.

6.7.3.3 Retorted Shale

The largest solid waste problem is the handling and disposal of retorted shale generated by the aboveground retorting facilities. Major considerations include site selection and preparation, disposal practices, water diversion and control, and reclamation.

The various aspects of the processed shale pile are discussed in the following Sections: 3.4.5, Spent Shale Handling; 6.3, Hydrology; 6.4, Water Quality; 6.5, Land Disturbance and Reclamation; and 6.8, Erosion.

The spent shale pile will contain shale retorted in the AGR, raw shale fines, the sludges identified above, and moisture from several sources. The objective of the analyses of the test plot described in Section 6.5.3 is to detect and characterize any leachate problems. The results of these analyses will be used to verify or modify the present design of the pile.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.7 Solid Waste

6.7.3.4 Raw Shale Fines

Fines separated from raw shale feedstock will be disposed with the retorted shale in the disposal embankment. The fines will be encapsulated with the spent shale and are not expected to pose an environmental problem.

6.7.3.5 Other Nonhazardous Wastes

Trash and other solid wastes will be collected and transported off-site to approved sanitary landfills.

6.7.3.6 Hazardous Wastes

Wastes identified as hazardous will be either sold to recyclers or removed from the site utilizing approved transporting and disposal facilities in accordance with RCRA. The only identified solid hazardous waste is the spent catalyst in the oil upgrader unit which removes the arsenic from the oil.

6.7.4 Environmental Effects

The hazardous catalyst (Section 6.7.3.6) will be returned to the manufacturer for reprocessing, or disposal in accordance with RCRA requirements.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.8 Erosion

TABLE OF CONTENTS

Page

LIST OF FIGURES

6.8 Erosion

This section addresses the various sources and effects of wind and water erosion and the control plan for the various disturbed areas of Tract C-b. Approximately 1600 acres of the C-b Tract will be disturbed over the life of the Project. The implementation of the Erosion Control Plan will necessarily evolve with the development of the Tract and the regulatory policy changes that may occur over the life of the Project.

6.8.1 Sources of Erosion

Areas devoid of vegetative cover are subject to wind and water erosion. The primary potential sources of erosion include:

1) Unpaved roads;
2) Disturbed areas associated with construction;
3) Topsoil storage embankments - prior to vegetation establishment;
4) Raw shale stockpile; and
5) Processed shale disposal embankment.

6.8.2 Regulations and Permits

6.8.2.1 Wind Erosion Regulations

The Prevention of Significant Deterioration (PSD) regulations and the state emissions permits are the main regulations dealing with potential sources of fugitive dust emissions. The standards concerning fugitive dust emissions and compliance, as well as the status of the PSD and state emissions permits are discussed in Section 6.2.2.

6.8.2.2 Water Erosion Regulations

The regulations and standards concerning water discharges have primary applicability to water erosion. Of prime concern is the National Pollutant Discharge Elimination System (NPDES) which is administered by the State of Colorado. Section 6.3.2 discusses the effluent limits of the NPDES permit, as well as the permit status.

6.8.2.3 Lease Requirements

Section 11 of the Lease requires compliance with all federal, state, and local water pollution control and quality, and air pollution control and quality regulations and standards. Previous sections have discussed these required permits and standards.

Sections 8 and 9 of the Lease Environmental Stipulations require that the Lessee make every reasonable effort to avoid, or minimize dust problems, and discharge of any toxic or saline water into a surface stream. Also, Section 11 of the Lease Environmental Stipulations states the Lessee shall submit, for approval, an Erosion Control Plan. This control plan sets forth the measures to be taken by the Lessee to avoid or minimize potential erosion. The following subsections contain the main component of the erosion control plan.

6.8.3 Erosion Potential and Erosion Control Plan

The most important consideration in the control of erosion is that of planning and scheduling. Disturbances associated with the construction of the mine and process facilities will be scheduled sufficiently close to actual construction to minimize time of exposure of unvegetated areas. In addition to

this fundamental control, various construction techniques will be employed to minimize the effects of wind and water on exposed surfaces. These on-site erosion control practices are designed to prevent soil particles from being detached. Water erosion controls will be backed up by sedimentation controls on the perimeter of construction sites to prevent detached particles from leaving the C-b Tract and entering Piceance Creek.

6.8.3.1 Wind Erosion Control

Prior to final or interim revegetation, and for those areas continually disrupted by materials handling activities, the primary control measure will be water sprays supplemented with chemical suppressants when water alone fails to reduce dust to acceptable levels. Emissions from these areas can be reduced by 50 percent with water treatments, which will be continued until sufficient revegetation stabilizes the exposed surfaces. The use of chemical suppressants can reduce emission levels by 85 percent. Roadways and construction staging areas will be controlled by water trucks equipped with sprays. Permanent roads will either be maintained in this fashion throughout the life of the Project or will be paved.

The most critical phase in the erosion plan is the construction period. At these times, exposed cut and fill areas are particularly susceptible to erosion. Other sources of wind erosion will be the raw shale stockpile and the ongoing construction of the processed shale disposal embankment. Concurrent with these activities, topsoil will be stripped and stockpiled for the permanent revegetation of the disposal embankment.

6.8 Erosion

The raw shale stockpile will be developed to contain the excess material generated prior to surface retorting. Topsoil will be stripped and stockpiled for later revegetation. Water sprays will be employed as needed to minimize fugitive dust, although the shale itself should be coarse enough to minimize wind erosion potential. An environmentally acceptable chemical agent will be used to further stabilize the raw shale stockpile if necessary. The topsoil storage embankment will also be controlled by water sprays until revegetation is sufficient to stabilize the pile (approximately one year).

The largest single disturbance during the life of the CB Project will be the construction of the processed shale disposal embankment. The disposal area will project above the surrounding ridges of Cottonwood and Sorghum Gulches, and thus will not be fully protected from the wind by the topography.

An alternative to this configuration would be to place a portion of the processed shale off-Tract to the south in the head of Sorghum Gulch (see Section 4.2.2).

The processed shale disposal embankment will advance in a northerly direction with topsoil being stripped ahead. As the top surface of the processed shale pile reaches the final elevation, the previously stockpiled topsoil will be replaced and revegetation begun. The procedure of simultaneous reclamation and processed shale disposal will be supplemented with water sprays at active pile areas when necessary to control fugitive dust emissions.

6.8 Erosion

Fugitive dust emission sources and controlled emission rates are given on Table 6.2-7.

6.8.3.2 Water Erosion Control

Proper storm water erosion control will be accomplished by the application of one or a combination of the following techniques:

1) Diversion of runoff around sensitive areas,
2) Diversion of upslope drainage,
3) Detention of runoff by ponds designed to contain 25 year storm,
4) Retention of runoff by ponds designed to control 100 year storm,
5) Reduction of runoff,
6) Proper handling and disposal of concentrated flows, and
7) Revegetation.

These techniques are currently being employed at the Mine Support and surrounding areas, and will continue with future development.

Diversions will be constructed to either direct upstream surface runoff around or through downstream disturbances, or to convey runoff from disturbed areas to sedimentation ponds for proper disposal. The diversion structures employed will be a combination of ditches, culverts, terraces and earth dikes.

That portion of Sorghum Gulch which is off-Tract and upslope of the designated processed shale disposal area has a drainage area of about 790 acres. The runoff from this acreage will be diverted into East Sorghum Gulch via a diversion trench designed to pass the flow from the probable maximum precipitation (PMP) event that could be expected to occur at the C-b Tract (6-hour PMP storm of 8.27 inches). The processed shale disposal embankment will extend to the head of Cottonwood Gulch thus eliminating any runoff into the disposal area at that point.

6.8 Erosion

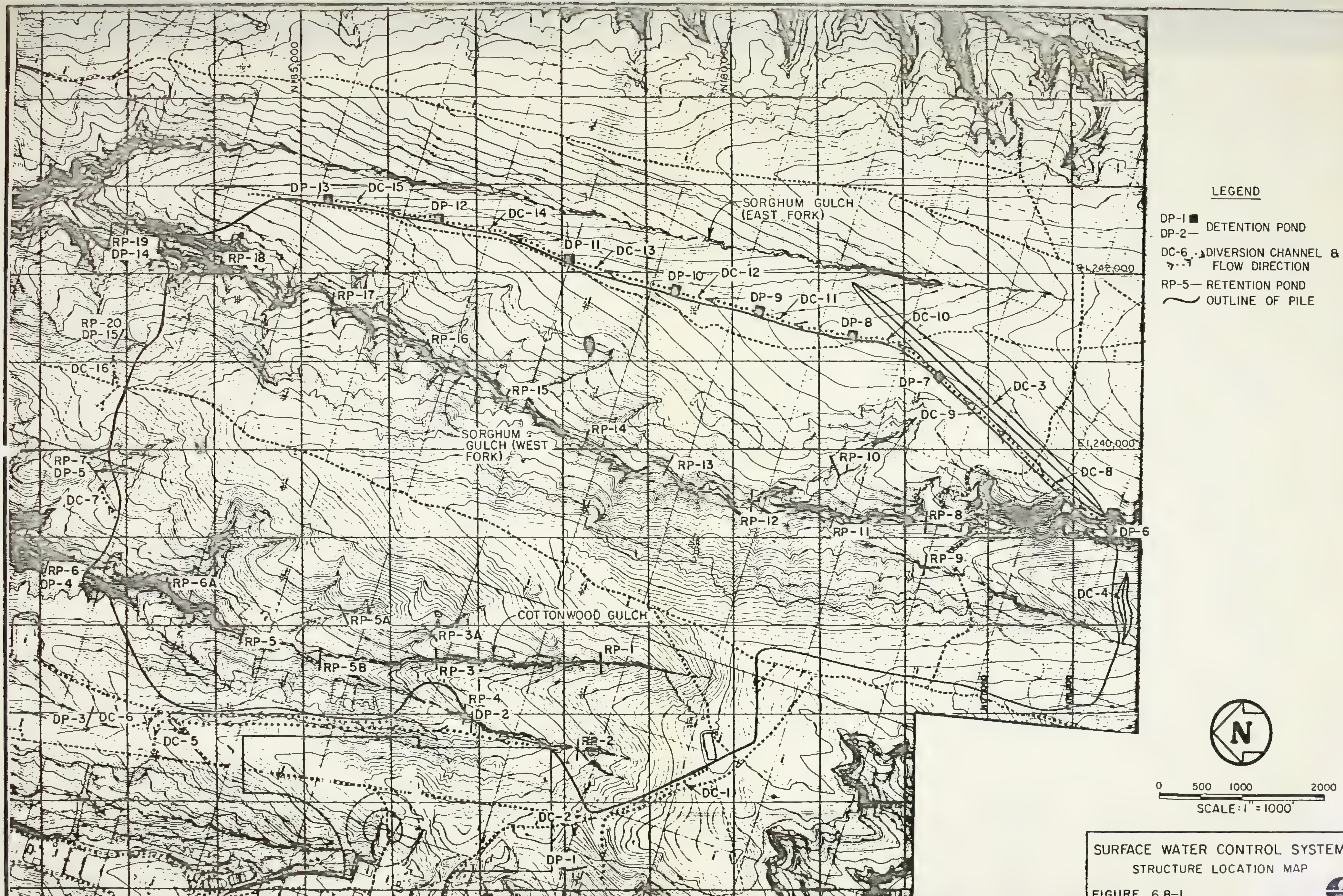
The control of runoff from the processed shale disposal embankment and areas where topsoil has been removed will consist of a series of temporary retention ponds just downstream of the processed shale embankment. Diversion channels will be used to channel runoff from the side slopes of the embankment into these retention ponds. These ponds are depicted in Figure 6.8-1.

The control of runoff from areas being reclaimed will consist of a series of collection channels and detention ponds. These ponds generally will be located along the east and west sides of the disposal embankment to provide for collection of runoff which will migrate in an easterly direction towards Sorghum Gulch. These ponds will be sized to provide a capacity to contain runoff resulting in a 25-year, 24-hour storm and control runoff from a 100-year, 24-hour storm (2.2 inches and 2.6 inches respectively).

The control of runoff from the raw shale stockpile will consist of constructing a retention pond just downstream from the stockpile. This pond will be sized to contain a 100-year, 24-hour storm.

The control of runoff from disturbed areas associated with mining and construction activities will consist of a series of diversion channels and sedimentation, detention ponds. The channels will divert the runoff from disturbed areas to the various locations of the detention ponds. These ponds will be designed to contain a 25-year, 24-hour storm and control a 100-year, 24-hour storm.

Reduction and detention of runoff from all disturbed areas will consist of grading and shaping the soil surface to trap rainfall, break up surface airflow, and afford protection to wildlife. This technique will be especially significant on the large surface area of the disposal embankment. A properly roughened and



SURFACE WATER CONTROL SYSTEM
STRUCTURE LOCATION MAP
FIGURE 6.8-1

loosened soil surface will enhance water infiltration, slow the movement of surface runoff and benefit plant growth. Common techniques of roughening the surface include tracking, scarification, furrowing and cross checking.

In addition to surface preparation, another means of reducing the rate of runoff from the disturbed areas will be that of reducing slope lengths and minimizing gradients. Benches will be constructed on the outslopes of all storage piles and the disposal embankment exposed slopes and thereby reduce erosion rates (see Figure 3.4-4). This technique will be followed on all cut and fill slopes. Benches will have a reverse slope back toward the hill, and will collect and discharge intercepted water into engineered diversion ditches.

The concentrated flows produced by the previously discussed erosion control techniques will be handled by rock riprap, rock check dams and culverts where applicable. These structures will dissipate the energy flow and shield sensitive areas from the erosive impact of the water. The primary means of handling the concentrated flow will be the sedimentation detention and retention ponds; these will also be the final barrier against the sedimentation of Piceance Creek. All applicable state and federal dam regulations will be considered in the design of these structures.

Retention ponds will be lined with an impervious material. Detention ponds will not be lined. The ponds will permit gravity settlement of suspended solids; evaporation will also occur. In addition to their primary function, these structures will facilitate monitoring and abatement of any leachates or other contaminants.

6.8 Erosion

The final erosion control treatment for both wind and water for all disturbed areas is that of establishing an adequate cover of vegetation through the use of proper revegetation techniques as discussed in Section 6.5.

6.8.4 Environmental Effects

The primary effect that erosion has on the environment is the removal of soil particles from one area with deposition occuring in another area. With approximately 1600 acres of surface area expected to be disturbed over the life of the Project, and thus being susceptable to the forces of erosion, the potential for impacts resulting from erosion is great. However, with a properly designed and implemented Erosion Control Plan, the potential environmental effects can be reduced to a minimum.

6.8.4.1 Wind Erosion

Wind erosion affects environmental parameters in the form of wind blown fugitive dust. Through the use of water sprays, and chemical suppressants, when needed, on exposed disturbed areas (areas lacking vegetative cover) and timely and successful revegetation of topsoiled areas, wind blown dust is not expected to have adverse effects (see Section 6.2.4).

Another parameter which may be impacted is visibility. According to the visibility impact analysis used in Section 6.2.4.3, significant adverse impacts on visibility are not expected to occur.

6.8.4.2 Water Erosion

Water erosion can increase sediment loads in streams, thereby affecting water quality, stream bed characteristics, and biota. Large erosive flows can alter stream beds and alluvial deposits.

6.8 Erosion

The proposed plan is expected to eliminate these adverse effects and may decrease the contribution of the Tract to sediment loads in Piceance Creek. In addition, the uncontaminated sediment ponds will provide additional water sources for wildlife. (Contaminated ponds, such as those in the process area, will be fenced and screened.) Implementation of runoff control measures on disturbed and disposal sites, by grading and shaping the soil surface to trap rainfall, should produce favorable microclimate sites for vegetation, thus assisting in the reclamation process.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.9 Subsidence

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.9 Subsidence

6.9.1 Sources of Subsidence

Subsidence resulting from mining activities could potentially be caused by 1) compression of pillars in room and pillar mines and resultant roof sag, and 2) consolidation of aquifer zones because of dewatering.

6.9.2 Regulations and Permits

There are no formal regulations or permits pertaining specifically to subsidence. However, subsidence is addressed by the OSPO in its review of the Mine Plan as part of this DDP. The Colorado Mined Land Reclamation Division requires that a hydrological monitoring program be performed at the site during the Project and that the occurrence of substantial surface disturbance be reported. A plan of reclamation must be submitted and a permit obtained.

6.9.3 Subsidence Control Plan

The subsidence control plan has two elements: mine design and monitoring. The mine is designed to prevent subsidence at the surface and underground, and above ground monitoring will substantiate the success of the design. If surface changes are detected, the mine design will be revised to achieve subsidence goals.

Surface subsidence is generally the result of the transmittal of some fraction of the mined void to the surface through caving, where it is seen as a depression or lowering of the original surface. This will not occur because substantial barrier and panel pillars will be left to support the overburden. No mine design is completely "rigid" since the extracting of even part of the tabular deposit will increase the vertical stress in remaining pillars. The pillars will compress and thus shorten in response to this increase in stress, but this deformation has been designed to be very small and will be virtually

unnoticeable underground. Pillar shortening in the panels will result in some roof sag, and there will be progressively less sag in the rock layers above the panel roof. Based on British National Coal Board and Eastern United States coal mine data, no effects of pillar shortening within the mining panel will be transmitted to the surface because the panel width is narrow compared to the mining depth. In addition, aquifers above the mining section will not be disrupted by the effects of pillar shortening.

Although dewatering caused by mining has the potential to induce subsidence, such is not the case on the C-b Tract for the following reasons:

1) The porosity of the oil shale deposit at C-b is very low (1-3%) in the aquifers being dewatered; thus, consolidation of the aquifer zones which would lead to subsidence, will not occur. As subsidence is controlled by the load bearing capacity of the contained liquid and the adjacent rock, this low porosity precludes any settlement.

2) Confined and pressured aquifers can result in subsidence when overlying rock is supported by fluid pressures. This is not the situation at C-b.

The control plan consists of a continuous subsidence monitoring program both on the surface and underground. The program will provide a record of the behavior of the ground surface and rock adjacent to the underground excavations. This information is needed to provide safe operating conditions, to detect environmental impacts, and to formulate guidelines for future mining and development of the Tract.

The surface monitoring program consists of: 1) leveling techniques for vertical displacements and 2) distance and angle measurements for horizontal and vertical displacements. The underground monitoring program consists of the mine survey network and resurvey to determine changes in vertical and horizontal

distances at regular intervals. Level lines and tiltmeters will be installed at appropriate shaft pillar and surface plant sites. Further details are given in Section 8.11.

If an unexpected amount of subsidence occurs and is detected by the subsidence monitoring system, the mine plan is flexible and can be altered to mitigate these effects. For example, the pillar spacings and/or dimensions can be redesigned to provide more support which would result in less pillar deformation and a corresponding reduction in surface and underground subsidence effects. Alternatively, if the monitoring shows less pillar deformation and associated subsidence than expected, the design will be incrementally relaxed to provide less support and thus result in higher extraction ratios and improved resource recovery. These control options depend on the actual ground conditions at C-b. Therefore, the mine plan has been designed to be initially very conservative and flexible to allow mitigation of ground condition effects.

6.9.4 Environmental Effects

The mine plan is designed to not produce any damaging environmental effects to the Tract. The primary effects that could be introduced by a mining project of this type are abrupt disruption of the shallow aquifers above the mining section and abrupt surface subsidence giving rise to large elevation changes in short horizontal distances. The mining extraction ratios and remaining pillar dimensions have been designed to support the overburden and preclude these environmental effects.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.10 <u>Noise</u>

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.10 Noise

6.10.1 Sources of Noise

Noise will be generated during the commercial development and operation of the C-b Tract. Activities that will produce significant above ground noise levels include: mine ventilation; hoist operation; material crushing, screening, stacking, and loadout; conveyor operations; raw and processed shale transport and stockpiling; aboveground retort operation; and vehicle and stationary engine operation.

Below ground noise sources include: blasting, mine face operations, vehicle and stationary engine and pump operation, and ore loadout facilities.

6.10.2 Regulations and Permits

6.10.2.1 Occupational Noise Levels

Occupational noise levels are prescribed aboveground by Occupational Safety and Health Administration (OSHA) and below ground by Mine Safety and Health Administration (MSHA). CB will continue to meet OSHA and MSHA requirements in personnel working areas. The occupational noise control plan is part of the Health and Safety Plan described in Section 6.15.

6.10.2.2 Environmental Noise

State noise standards for an industrial zone are explicitly stated in Section 8.7.2 on noise monitoring and apply within 25 feet of the Tract boundary. The Lease requires monitoring of environmental noise as described in Section 8.7.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.10 Noise

6.10.3 Noise Control Plan

Tract areas will employ recent noise attenuation technology sufficient to assure levels which meet federal and state standards. The following programs will be incorporated to minimize the impacts of environmental noise:

1) Monitor noise levels in both work and ambient environment to detect and define high noise levels.
2) Require the use of hearing protection devices when warranted.
3) Specify equipment with built-in noise reduction technology, as appropriate (e.g., conveyors will be covered).
4) When practicable, locate noisy activities in areas where noise can be attenuated by distance or barriers.
5) Maintain equipment in good working order (e.g., mufflers will be inspected regularly).
6) When practicable, schedule noise related activities at times that will minimize the exposure of noise recipients.

6.10.4 Environmental Effects

CB recognizes that the data on effects of noise on wildlife are minimal and controversial. It is felt that the principal reaction of fauna to noise is merely to move away from the source to a point where it is of no concern or impact. Because of the rapid attenuation of noise intensity with distance, such translocation is expected to be only a few hundred yards. A certain amount of noise conditioning is also expected.

Potential health effects of occupational noise are discussed in the Health and Safety Control Plan, Section 6.15.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.11 Fish and Wildlife

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.11 Fish and Wildlife

The Fish and Wildlife Management Plan delineates habitat losses which will occur and mitigation efforts to replace in kind or to improve alternative habitat for selected species of animals. This plan is dynamic and will be updated and revised as new information becomes available. Because this plan was developed in cooperation with the Colorado Department of Wildlife (DOW), BLM and OSPO, any revisions will be developed cooperatively and in coordination with the regional Piceance Basin Wildlife Habitat Management Plan (1972), with final approval of the OSPO.

6.11.1 Activities Affecting Fish and Wildlife

Many of the activities entailed in developing an oil shale project may affect the fish and wildlife in the area. These activities will include: 1) habitat alteration and/or destruction, including reclamation and mitigation activities; 2) increases in human activity on-site and recreational use off-site; 3) increased access due to new roads and right-of-ways; 4) increased traffic on highways; 5) visual and audible disturbance due to machinery and plant operation; 6) dewatering activities; and 7) hazards associated with accidental petroleum and toxic chemical spills. Other activities in the region that may affect fish and wildlife are the growth of towns and increased water demands.

6.11.2 Summary of Lease Requirements

Section 4 of the Lease Environmental Stipulations requires that the Lessee submit a fish and wildlife management plan for the following purposes:

1) to meet the requirements of Stipulations which state that "the Lessee shall submit ... a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is

unavoidably destroyed or damaged; 3) provide alternative habitats; and 4) provide controlled access to the public for enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedules, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife.

2) to provide information necessary to satisfy requirements of the Stipulations concerning mitigation of damage to fish or wildlife habitat, which includes the formulation of measures to "avoid, or, where avoidance is impracticable, minimize and repair injury or destruction of fish and wildlife and their habitat; as a general rule, the proposed measures should provide for habitat of similar type and equal in quantity and quality to that destroyed or damaged."

3) to provide information necessary to determine when and where it may be necessary to construct big-game drift fences in the vicinity of the Tract to direct big-game movements around or away from oil shale development areas.

6.11.3 Fish and Wildlife Plan

This plan addresses activities on the Tract from the time of development planning to post-operation decommissioning. The primary geographic scope of the plan incudes the area of the Tract and the areas off-Tract that would be affected by on- and off-Tract activities.

Basin-wide historical information, along with the data being obtained in baseline aquatic ecology and fauna studies have been utilized to analyze the significance of the Tract in the regional setting with respect to animal use and adjacent aquatic habitat.

6.11 Fish and Wildlife

The plan includes general policies as well as specific procedures to minimize adverse effects from development on fish and wildlife. Procedures to enhance and maximize potential positive effects are also included. The plan specifies the provision of alternative habitat and other special programs.

General policies and specific procedures have been developed to coordinate plans with government agencies and appropriate private entities. As development proceeds, the monitoring programs set forth in Section 8.0 will indicate the effectiveness of the mitigation procedures. In the event that procedures are shown to require modification, these modifications will be made with the approval of the OSPO. Specific plans for mitigation will be submitted for approval to the OSPO 60 days prior to CB actions that could affect fish or wildlife habitat.

6.11.3.1 Habitat Conversion

The main thrust of the mitigative measures will be to provide alternative habitat for wildlife displaced by CB activities by increased production in on- and off-Tract areas. For instance, the south-facing slopes are extremely important to wintering mule deer, and they lie within a known deer concentration area. In these areas there will be both short- and long-term mitigation projects. Fertilization will render immediate increases in productivity and is considered to be short-term. Brush beating will encourage new growth of forage for deer. This is considered a long-term mitigation project because beneficial effects of the beating may well last for years.

Habitat improvements outlined in the Piceance Basin Wildlife Habitat Mitigation Plan (HMP) may also be of mitigative value. These include Stewart Gulch brush beating and seeding 75 acres for elk, deer, and cattle, a project CB will implement. As with improvements to the north of the Tract, HMP projects will be studied in cooperation with the BLM, DOW, and OSPO. Habitat improvements

will increase browse for deer and forage for livestock at least to the extent that the estimated loss of habitat for 150 deer and 235 cattle animal unit months (AUM) are mitigated. Critical early spring deer habitat near Piceance Creek on south-facing slopes above Piceance Creek will also receive attention.

One mitigation measure already in progress is a sagebrush modification project in two draws north of the Piceance Creek road. Approximately 100 acres of mature bottomland sagebrush (varying 5 to 10 feet in height) was chopped using a brush cutter. Both areas were reseeded with grass and browse species. Depending upon the success extent of increased forage production and increased use by livestock and wildlife, brush beating may be used as a habitat improvement technique in other sagebrush draws. Alternatives to sagebrush modification projects listed in the Piceance Creek HMP are on-Tract projects in Scandard and West Stewart gulches. Also, larger areas are found both north and south of the Tract. Various subspecies of sagebrush may be planted in the new beating areas. These plantings would extend across the entire draw in order to test their adaptability to the areas and their palatability to deer. In addition, the BLM has suggested sagebrush burning on North Ridge (north of Little Hills) to improve deer winter range.

A meeting was held with personnel from the DOW, OSPO, and BLM to determine possible mitigation projects. Several possible projects were identified as follows:

1) Consideration is being given to a seeding and transplant study on some critical south facing slopes. CB wildlife studies and the DOE telemetry study of migrational patterns have shown that mule deer move off the Tract in late winter to these relatively snow-free slopes in mid-winter. It is thought that the browse and forb species on these slopes could be

increased through broadcast seeding, transplants and fencing. Several small plots would be established to test techniques and success rates of various treatments.

2) Another possible mitigation project is a serviceberry beating south of C-b Tract. This project would be done to increase browse production for elk and deer. The serviceberry is about 6-8 feet tall and beyond reach of deer and elk. Beating the shrubs should encourage regrowth and provide more available serviceberry for deer and elk to utilize.

3) Burnings and fertilization projects in the chained areas are being considered. In 1978 a 320 acre fertilization project was carried out in the chained area. The project was intended to stimulate production and utilization of the forage in the area used by deer and livestock. Results of the project showed that the rate of fertilizer application would have to be increased to achieve a significant change in forage production and utilization. To ensure that the fertilizer is not tied up by microbial organisms in the litter, (instead of being available to the plants), some of the slash may have to be burned or removed. Several treatments may be tried in the previously chained areas including seedings and water applications.

4) There are approximately 1,500 acres of pinyon-juniper between Willow Creek and Big Jimmy Gulch that could be chained. Potential chained areas will be divided into small irregular blocks of 40 acres or less to simulate natural parks. It may be necessary to fertilize the chained areas to increase forage production and palatability. Fertilization may be a rapid method to improve habitat; whereas chaining returns benefits over a longer time.

6.11 Fish and Wildlife

5) Reduction in cattle AUM's may be mitigated to some degree by sagebrush modification. It would be desirable to improve the habitat of the drainages north of the Tract such as the large sagebrush greasewood flat that exists on Piceance Creek north of the Tract. Because the flat is on deeded land, agreement with the land owners would be needed. The are area should be cleared of brush and seeded to a highly productive wheatgrass. If no water were available, a dry land pasture would be much more productive than the existing vegetation. The early green feed will also benefit the deer.

6) For the benefit of both wildlife and livestock, several water projects are planned. With the exception of Piceance Creek, there are very few places to water wildlife and livestock on or near C-b Tract. In addition to providing water for livestock, fencing may be established to improve the livestock grazing patterns.

7) In chained areas, the remaining debris will provide cover for small mammals. Small mammals preferring pinyon-juniper will be reduced at the expense of those preferring grass and brush types. Rabbits will benefit by the chaining and sagebrush modification. Scattered small islands of pinyon-juniper will be left in chained areas to reduce the impact on birds preferring tree-types for nesting.

Mitigative measures will be scheduled in accordance with the development of the Tract. Many of the mitigative measures will be initiated in the first five years of the Project. To maximize success of the habitat enhancement program, CB will coordinate with the Bureau of Land Management on livestock grazing management during critical phases of the improvement program.

6.11.3.2 Habitat Restoration

The Land Disturbance and Reclamation Plan (Section 6.5) discusses contouring and revegetation of the processed shale pile and other disturbed areas. This plan will address itself solely to the type of vegetation desired on the processed shale pile.

The goal of the plan is to establish a self-sustaining vegetation type as productive and diverse and as supportive of wildlife as the vegetation in existence before disturbance. Toward this end a wide variety of species will be included in the seed mixture.

Research on processed shale by Union Oil Company, Berg at Anvil Points, Redente in the Piceance Basin, and CB indicates that grasses will dominate on the more favorable sites and shrubs will dominate on the less favorable sites. Redente and CB have found revegetated processed shale with 12-inches of soil to be as productive as pre-disturbance vegetation. Most range sites in the Piceance Basin are rated between poor and fair prior to oil shale disturbances.

6.11.3.3 Vehicle-Wildlife Collisions

Preventive actions will be taken to mimimize incidences of collisions between deer and vehicles that would be caused by increased traffic, and result in risk of injury or loss of human and animal life, and vehicular damage. Mass seasonal migrations of deer across highways and the daily movements of many deer between cover and foraging areas accentuate the potential problem on the Tract area.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.11 Fish and Wildlife

CB's objectives for preserving wildlife are: 1) minimization of deer mortality resulting from deer-vehicle collisions; 2) reduction of the risk of accidents causing injury to humans resulting from deer-vehicle collisions; 3) minimization of the economic costs of collision-prevention systems and economic losses resulting from collisions; and 4) cooperation with regional programs for deer-vehicle collision prevention.

In conjunction with the Division of Wildlife, CB has been monitoring road kills along the Piceance Creek Highway since 1977. Deer mortalities are recorded according to location, age, sex, and animal conditions. The interrelationships between road kill, traffic load, weather, etc., are being studied for possible solutions to reducing the road kill. To help reduce road kills, bus service has been provided to CB workers living in Meeker and Rifle. The employees are made aware of the potential deer-automobile collisions through signs, literature, and lectures. Traffic counters have been installed to estimate the traffic load on the Piceance Creek road and on the Tract access road.

The Tract access road has seemed to have little effect on the deer to date, based on C-b studies and results from the DOE study. To reduce the chance of deer-vehicle collisions on the Tract, maximum permissible vehicle speed on secondary roads will be 25 mph.

A deer reflector study is being implemented by several agencies and companies including the Colorado Division of Wildlife. The study is testing the effectiveness of deer reflectors in reducing deer vehicle collisions along the Piceance Creek road.

If deer-car collisions become a problem, a cooperative venture will be started with the Division of Wildlife to help remedy the problem. The use of deer fencing, underpasses, additional use of reflectors and other feasible methods will be considered. The fencing alternative will use as little fencing as necessary to achieve protection of deer and humans and still assure that migration and daily movements of deer and other wildlife species will not be hampered. The fences will be located and designed to minimize their visibility. Principle deer movements follow north-south paths. To permit such movements, underpasses, should they be necessary, will be located at appropriate positions along the Piceance Creek road deer barrier. The exact method or methods used to solve any deer-car collision problem will be determined if and when such problems arise.

6.11.3.4 Human Activity

The presence of people and companion animals moving about on foot may have a greater effect upon the distribution and behavior of wildlife than the presence of buildings and vehicles. This type of wildlife disturbance will occur during all periods of development.

Several methods will be used to minimize unnecessary disturbance to wildlife: 1) informational and educational program for workers on adverse effects of extra-vehicular activity and wildlife harrassment, 2) restriction of extra-vehicular activities by personnel, 3) limitation of activities in critical areas, 4) limitation or control of parking along roads controlled by CB, and 5) control of pets.

The proposed control strategy includes informing all construction and operating personnel of their responsibilities with respect to fish and wildlife laws, and cooperating actively with law enforcement personnel. The informational

program will include posting bulletins in all personnel offices, change rooms and recreation halls, and distributing relevant regulations to all employees. Wildlife conservation officers will be allowed ready access to the Tract. The promotion of good attitudes toward wildlife will also be fostered by supporting sports, nature and conservation groups. Current game, fish and related regulations will be posted on bulletin boards, and brochures regarding these regulations will be distributed to all employees. Also, harassment of wildlife, excessive land disturbance, and other actions which detrimentally affect the environment will be policed.

6.11.3.5 Access Management

Continued provision for public access to the Tract to allow appropriate opportunities for harvest and non-harvest uses of wildlife resources is a requirement of Section 4(A)(4) of the Environmental Stipulations to the Lease. Public access requires careful supervision because of the difficulties in maintaining adequate security and safety. The public will be allowed access to and through those parts of the Tract that are not critical to Plant operation or do not pose health and safety problems.

CB will continue to provide public access to the Tract at a level comparable to that during the baseline period, where such access is compatible with security and safety. Procedures for implementing these policies include fencing critical Plant-Mine areas, the use of security guards, and prohibition of firearms in areas where they would create a safety hazard. Areas where machinery is operating on the disposal pile will be restricted. Also, no vehicle traffic will be allowed on the shale disposal piles where revegetation is underway.

6.11.3.6 Growth in Regional Human Population

It is recognized that development and operations on the Tract will contribute to the human population growth of Rio Blanco and Garfield Counties

(see Section 7.0) that will, in turn, affect wildlife. Negative effects upon wildlife will be caused by modification of wildlife habitats for housing, business, and transportation; diversion of water from current uses to commercial and industrial uses; and wildlife disturbances resulting from increased outdoor recreation. These effects will occur during all periods of development. CB will cooperate with other firms, agencies, organizations, and individuals to coordinate wildlife management programs throughout the region in an effort to mitigate adverse effects.

6.11.3.7 Erosion in Terrestrial Habitats

Site development and construction activities, including roads and pipelines, can result in erosion which affects contiguous habitats and reduces their ability to support vegetation and wildlife. CB's objectives in mitigating erosion include: 1) minimizing areas to be disturbed; 2) minimizing the length of time that any area will be subject to disturbance; and 3) restoring natural habitats on disturbed areas. Methods of erosion control are addressed extensively in the erosion control and surface rehabilitation plans (Sections 6.5 and 6.8, respectively).

6.11.3.8 Modification of Aquatic Habitats

The destruction or modification of aquatic habitats on the Tract is expected to be negligible, due to the lack of such habitat. Habitat modification may result from site preparation, stream crossings, diversion of natural emphemeral water courses, inundation of a natural stream by a reservoir and the deposition of the processed shale. CB will strive to avoid disturbing aquatic habitats when possible, and will design and construct facilities in such areas to minimize impacts.

6.11.3.9 Erosion and Siltation Affecting Aquatic Habitats

Erosion may result in destabilizing conditions in aquatic habitats, and increasing turbidity and siltation. Modification of vegetative cover adjacent to aquatic systems or water courses is the primary cause of increased erosion. The resulting increases in turbidity and siltation rate are generally detrimental to aquatic organisms, especially benthic macroinvertebrates and fish. High levels of tubidity can limit the productivity of algae and aquatic macrophytes, the primary producers in aquatic ecosystems. All site development and construction activities could potentially contribute to this problem. Erosion control will be accomplished through the use of methods given in the erosion control and surface rehabilitation plans. The basic objectives are to: minimize erosion and siltation and, where this is unavoidable, to mitigate adverse effects on aquatic habitats.

6.11.3.10 Water Pollution Affecting Aquatic Habitats

The Stipulations regarding federal and state water quality standards prohibit discharges to any stream or tributary, unless such discharges meet water quality standards. Thus, no direct water pollution as a result of development activity is expected. Accidental discharges resulting in stream pollution are addressed in the Spill Prevention Control and Countermeasure Plan (Section 6.6).

6.11.3.11 Reduction in Groundwater

Modification of terrestrial and aquatic habitats will result under the highly unlikely circumstances that there was a significant reduction in springs or seeps flow. Impacts include the possible reduction in flow of a portion of Piceance Creek and reduction of water levels of ponds. Some terrestrial habitat, notably the greasewood and riparian communities, depends to an extent on springs and seeps as a source of water. Irrigated pastures along Piceance Creek depend upon managed groundwater discharge because Piceance Creek is largely spring-fed.

Consequently, changes in groundwater availability can influence distribution and composition of these communities, as well as their capacity to support wildlife.

Mine dewatering could potentially effect local and possibly more distant groundwater discharge. Data and information derived from the CB's hydrologic testing program indicate that dewatering operations can be conducted in a manner that will have little effect on springs and seeps in the vicinity of the Tract. The effects of dewatering will be monitored carefully and remedial action taken if detrimental effects occur. Such action could include additional sealing and grouting in the mine shafts to reduce the amount of groundwater entering the shafts and providing supplemental water for Piceance Creek. The flow of Piceance Creek will be managed through the water rights priority system and augmented if necessary. See Section 6.3, Hydrology.

6.11.3.12 Effects of Air Pollution

Plant facilities will be designed to meet federal and state air quality standards, which have been promulgated to protect the public health and welfare. Air pollution-related effects are addressed in the Air Quality Control Plan (Section 6.2).

6.11.3.13 Effects of Noise

Noise from road travel, construction and plant machinery, and processing units may affect the behavior and distribution of wildlife, such as deer. However, deer are known to acclimate rapidly to repetitious or familiar noises. Raptors are sensitive to loud noises, especially during the nesting period.

The objective of CB is to minimize potential consequences of noise on wildlife species. Noise control plans which will serve to mitigate these potential effects are the same as those proposed for humans and are described in Section 6.10.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.11 Fish and Wildlife

6.11.4 Environmental Effects

The major effects of the proposed operation (after above mitigation procedures are implemented) will be changes to the habitat of small mammals and summer bird populations presently utilizing the surface areas that will be disturbed. Since the habitat in surrounding areas is similar, limited animal movement from disturbed areas will occur, with some repopulation and recolonization of the surrounding undisturbed areas. After rehabilitation and restoration of disturbed areas, repopulation and recolonization may proceed by emigration from surrounding undisturbed areas. After reclamation the land should be able to support animal populations equivalent to those now present.

During the mine development phase, the greatest effect on the deer populations will probably be increased road kills as a result of increased traffic. In addition to mule deer, other animals occasionally killed by road traffic include other big-game species, small and medium-sized mammals, birds and reptiles. However, the cumulative adverse effect of the proposed roads and traffic in the Piceance Creek area on these species is expected to be minor.

Small mammals will probably undergo local population modifications and an overall reduction of numbers and density with habitat destruction. There will also be minor shifts in composition and diversity. For example, deer mice will probably increase while the sagebrush vole, which is at its southern limits of distribution, and the Apache pocket mouse, which is near its northern distributional limits, will likely diminish in number. There may also be a decrease in the abundance of the three species of chipmunk (the least, Uinta and Colorado), but at this time it cannot be predicted what changes will occur in these populations due to modifications in habitat.

6.11 Fish and Wildlife

Changes in habitat and the presence of man will probably reduce, locally, the numbers of certain species of song birds. Birds, such as the chickadees and pine siskins, which inhabit wooded areas will probably stay away from the cleared areas where human activities are occurring. On the other hand, an increase in flock-like species, such as horned larks, that inhabit open areas will probably occur.

Raptor populations in the area may decrease, although raptor eyries and principle nest sites are not located close to the development areas. If substantial changes in mammalian populations occur, changes may also occur in the abundance of certain raptor species. However, the small percentage of habitat to be disturbed relative to the total extent of similar habitats in the region suggests that local reductions in small mammal numbers should not have significant consequences on the habitat of wide-ranging raptorial species. As a result of the increased presence of man, poaching could have an impact on raptors. Waterfowl and upland game birds will probably experience minimal disturbance, although poaching may affect both populations.

The preferred habitats of most reptilian species are the rocky, south-facing valley slopes and the densely vegetated valley areas near streams. Changes in these preferred habitats and, consequently, effects on these species, are expected to be negligible. There are no endangered reptilian or amphibian species in the area and no critical habitats that will be significantly damaged.

Fish and aquatic invertebrates should not be affected as a result of the shaft sinking and mine development since it is unlikely that the surface water flows will diminish. Piceance Creek has a high siltation rate during spring runoffs. Siltation resulting from erosion during construction activities will be controlled, but some runoff may occur which could degrade water quality and adversely affect aquatic species, especially if occurring during fish spawning periods. As stated in Section 2.5.4, the lower Piceance Creek has poor water

quality and below Stewart Gulch has been designated as Class 2 warm water aquatic life, agriculture and Class 2 recreation. If degradation were to occur it would only affect sparse members of a few non-game fish species.

A precise determination of the consequences of visual and audible disturbances of fauna is not possible because of the lack of behavioral information and the uncertainty regarding the degree of disturbance attributable to such factors. These disturbances will be local because they will not extend more than a mile from the source, except under very unusual circumstances. It has been found that deer adapt to human activity and noise. To date, operations on the C-b Tract appeared to have had little influence on their overt behavior. During the construction activities in 1978 deer moved into the construction areas after the equipment was shut down for the night. Preliminary data for the DOE study shows that deer remained near the construction activities throughout the winter.

The areas utilized most intensively by mule deer between October and April are off-Tract in Piceance Creek valley and the contiguous south-facing slopes. Nevertheless, deer also range over the entire Tract through much of the winter. Preliminary investigations of the Tract region indicate that winter deer concentrations are generally higher in the immediate Tract vicinity than in areas a few miles from the Tract. The fringes of pinyon-juniper along Sorghum and Cottonwood Gulches serve as travel corridors for deer moving to and from Piceance Creek during migration.

The presence of the on-Tract facilities, spent shale pile and human activity may cause deer to use other areas. It is estimated from baseline data that approximately 120 deer may be displaced annually. The productivity of nearby

undisturbed areas will be increased through various mitigation techniques to offset the loss of habitat. Thus, during the life of the Project deer will be displaced; however, alternative habitat will be provided. After abandonment, deer habitat on-Tract will be reestablished.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.12 Scenic Resources

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.12 Scenic Resources

6.12.1 Activities Affecting Scenic Resources

As described in Section 2.6, a substantial study was undertaken to determine the type and quality of scenic resources in the vicinity of Tract C-b. As depicted in Figure 2.6-1 the only Class A area (the highest scenic value) is the Piceance Creek road corridor. The Tract itself consists of Class B and C areas, with the latter comprising 45% of the Tract (the chained areas). Therefore, the overriding conclusion of the study is that the Tract is of relatively low scenic value. Construction and mining activities are expected to affect scenic values on Tract to some extent.

6.12.2 Regulations

Section 12 of the Lease Environmental Stipulations addresses both scenic values and aesthetic issues. Regarding the former:

1) In design and construction, contours compatible with the natural environment shall be used to avoid straight lines;
2) Natural colors in painting facilities shall be used;
3) Small natural openings shall be used wherever possible in building construction and land disturbance;
4) Minimize disturbed land not under revegetation;
5) Contouring under reclamation shall simulate natural topography.

Regarding aesthetic values, all buildings shall blend with the natural landscape to the maximum practicable extent. Signs shall be rustic and conform to BLM sign standards.

6.12.3 Visual Management Guidelines

In effect, the stipulations under the Lease, as described above, become the guidelines for scenic and aesthetics considerations and will be followed, where practicable.

Specific procedures for this control plan that the Lessee intends to use in designing, clearing, earthmoving, and construction are as follows:

1) Large volumes of material will be placed where practicable so that the longitudinal axes are parallel to the existing ridge and creek patterns. Outlines will be shaped similar to the ridges of the surrounding area. Gentle undulations matching local draws and gullies will be copied insofar as possible. Straight lines of cuts and fills as well as other surfaces will be contoured and broken as much as possible so as to form loose, informal and natural-looking slopes. Irregularities of slope will be concentrated near the base of fills and tops of cuts with areas toward the roadway remaining geometrically more formal. This provides a gradual change from straight to natural lines and surfaces. Existing terrain features such as ridges, draws, gullies, etc., will be used as a guide to shape, mold, fill and cut slopes.

2) Surface materials have a great influence on revegetation efforts and topsoil or seed bed requirements must take precedence over other considerations. However, where coarse material must be used to protect surfaces from rapid runoff, slopes will be built to resemble natural banding. If possible, surrounding natural irregularities will be repeated and matched, and embankment slopes blended into the surrounding natural terrain.

6.12 Scenic Resources

3) New vegetation will be blended in by the proper combination of revegetation and geometric placement. Vegetative cover will be selected that is similar to surrounding native types.

4) Features will be designed to blend into a composite landscape design that is not only aesthetically pleasing, but preferable from an operations and maintenance viewpoint. Properly constructed and revegetated, even cuts as well as embankment slopes will become a part of the landscape.

5) Slope rounding, which eliminates pronounced and artificial-looking edges of the cut and fill, will be done wherever possible. Sharp edges and uniform large surfaces will be avoided. Whenever possible, long uniform slope areas will be slightly undulated and warped to form side draws and small ridges.

6) For aesthetic reasons and also to minimize erosion damage, efforts will be made to conserve existing vegetation near or along the edge of the Project facilites.

7) Particularly in valley bottoms or along natural runs, slope rounding can be modified, and with some special placement of larger rocks, islands of trees or shrubs may be preserved.

8) All structures will be colored, painted and textured to blend readily into their surroundings.

6.12.4 Environmental Effects

Particularily for the Class A (highest scenic area) along Piceance Creek road virtually no environmental effects are apparent. Inasmuch as the Tract ultimately returns to its original state, on-Tract effects will be both minimal and temporary by adhering to the above guidelines.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.13 Cultural Resources

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.13 Cultural Resources

6.13.1 Activities Affecting Cultural Resources

Archaeologic and historic resources on Tract are identified in Section 2.7. According to the investigating archaeologist, no cultural resources have been found that would prevent further development of the mineral resources on the Tract.

Sites 5RB136 and 5RB146 (Figure 6.5-1) are the only sites deemed worthy of future consideration in the development of Tract C-b. The other recorded sites in and near the Tract will require no further study as they either have very little potential or have already been destroyed by human or natural factors.

An envelope (i.e., boundary limits) of the maximum projected disturbed areas on Tract is presented in Figure 6.5-1. None of the disturbed areas overlap with any of the on-Tract archaeological sites.

6.13.2 Regulations

6.13.2.1 Federal Antiquities Permit

The field work done on the Tract in 1974 was conducted under Federal Antiquities Permit 70-CP-055.

6.13.2.2 Lease

Section 6 of the Lease Environmental Stipulations has the following two requirements:

1) Cultural Investigation - Lessee must conduct a thorough investigation prior to development for objects of historic or scientific interest and report such findings to the OSPO, and

2) Objects of Historic and Scientific Interest - Lessee may not remove, injure or deface any objects of historic or scientific interest. The OSPO will make the determination in questionable cases.

6.13.3 Mitigation Plan

For the Project's proposed disturbed areas (Figure 6.5-1), known archaeological sites will not be disturbed. If the area to be disturbed were increased beyond that shown in Figure 6.5-1, due to circumstances unknown at this time, an attempt will be made to avoid known pre-historic and historic sites. If avoidance is not possible, these sites will be investigated further in consultation with the OSPO to determine the appropriate mitigation action.

If during construction, new "finds" are discovered, they will be evaluated by qualified professional personnel. If earth moving reveals an object on the site, work will be halted until experts can evaluate the find. Notice of any discovery will immediately be given to the OSPO.

All employees will be briefed on the nature of scientific resources that might be located on-Tract based on past surveys.

6.13.4 Environmental Effects

By virtue of the investigation plans described above and because no items of cultural and historic interest have been identified in the proposed development area, no environmental effects of the proposed Project are anticipated.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.14 Fires

TABLE OF CONTENTS

Page

6.14 Fires

The potential for accidental fire exists in many of the underground activities and on the surface. However, reasonable mine and process design and proper operational safeguards will minimize both the protection required for and the consequences of this hazard. A comprehensive plan will be developed to identify those sources having potential to cause accidental fires as well as procedures for preventing and controlling them.

6.14.1 Potential Fire Sources

Much of the material, equipment, and structures at Tract C-b will be vulnerable to fire. Primary concerns are fuels and lubricants, diesel and electric powered equipment, electrical circuits, explosives (ANFO), trash, lumber, and structures.

Raw oil shale is also a flammable material -- the higher its grade, the easier its ignition. Spontaneous heating has occurred but only in surface piles of finely broken high grade shale. The ignition of a broken shale muck pile from a blasted round has been reported in one instance.

6.14.2 Regulations

The Oil Shale Lease requires the lessee to prevent, control and supress fires on land subject to the Lease. The Lease, local, and state regulations require compliance with National Fire Codes on handling, transportation, storage, use, and disposal of flammable liquids, gas, and solids. OSHA and MSHA regulations will be applied to surface and underground operations as appropriate.

6.14 Fires

6.14.3 Fire Control Plan

6.14.3.1 Fire Prevention Measures

6.14.3.1.1 Fuels and Lubricants

Underground storage of diesel fuel will be limited to those quantities consumed on a single operating shift. Storage and fueling operations will occur in specific areas near a return air course. Dry-break systems for fuel and lubricant transfer will minimize spillage. Should a fuel fire occur, it will be controlled with fire suppression systems or the dry chemical extinguishers mounted on all equipment or, if necessary, by a fire truck using high pressure fogging nozzles and/or foam extinquishers.

6.14.3.1.2 Equipment

Appropriate sensing and alarm systems and dry chemical fire suppression systems, in addition to the portable dry chemical extinquishers carried on all mobile equipment, will be used for fire control.

6.14.3.1.3 Electric Circuits

Fire prevention measures will involve use of proper overload circuit breakers and the repair or replacement of damaged circuits and equipment as indicated by an ongoing inspection and maintenance program.

6.14.3.1.4 Explosives

Large quantities of this material will not be stored in the mine but will be supplied from the surface as needed on a daily basis. Proper procedures for transport and frequent vehicle maintenance will minimize fire hazards.

6.14.3.1.5 Supplies and Trash

Storage, use, and disposal of these materials will be controlled. Trash from underground shops, warehouses, and lunchrooms will be disposed in self-extinguishing containers provided for this purpose. Waste from such containers will be periodically collected and hoisted to the surface for disposal.

6.14.3.1.6 Oil Shale

Although normal safety measures will be implemented, CB does not anticipate a heat or combustion problem. The CB raw shale storage pile will contain only coarse material and in this state it is not amenable to heating. CB has not experienced heating problems with the shale that has been stored on-site for several years. In addition, the raw shale storage pile will be depleted within a few years.

The shale fines from the crusher will be cooled before being deposited in the retorted shale pile. These fines will be mixed with the other material in the pile and will not pose a heating problem.

6.14.3.1.7 Surface Wildland and Structure Fires

Mobile fire trucks and equipment will be available for surface fires. Personnel will be trained for control and suppression of any fires on the leased lands.

6.14.3.2 Fire Fighting Procedures

Any indications of a fire will be reported immediately via the central communications system to the fire control coordinator. Upon receiving a report of a possible fire and its location, the fire control coordinator will dispatch

6.14.3.2 Fire Fighting Procedures

appropriate personnel and fire fighting equipment. Unless specifically determined to be unnecessary, he will initiate evacuation of all but emergency personnel along prescribed and posted escape routes.

Emergency fire fighting equipment will be maintained underground and will be manned by specifically assigned and trained personnel. Fire trucks will be equipped to fight fires of all types and will be supported as necessary by the mine utility water system.

Preparedness training will be conducted regularly for all emergency crews. Instructions on fire control and evacuation procedures will be given to all new employees. Self rescuers and instruction on evacuation procedures also will be provided for all visitors to the mine.

The CB surface facility fire protection system is divided into two distinct types of fire protection: a wet system and a dry system. The wet system may be utilized in both interior and exterior areas.

The interiors of buildings are protected by either sprinklers or hose cabinets. The shop area is to be protected by sprinklers. The interior areas of all other buildings shall be equipped with hose cabinets each with 75 feet of hose and a fog nozzle.

The building exteriors and adjacent areas will be protected with fire hydrants. Fire hydrants shall be spaced such that no facilities are further than 250 feet from a hydrant. The hydrants shall be sized such that each

hydrant can provide a flow of 500 GPM divided into two streams. Each hydrant will have connections of two 2-1/2 inch fire hoses with one common valve.

The fire system will be sized to provide flow for one major fire. The fire water system will have the capacity to supply 150% of the required fire water pumping rate of 5000 GPM and 150 psig delivered to the distribution system. The fire water tank will contain 63,000 Bbls.

Areas near hydrocarbon storage tanks will be provided with monitor nozzles. Some areas of the facility will require a "dry" type of fire protection, such as a Halon system. These sources requiring "dry" protection primarily contain electrical equipment, and are located in areas such as the headframes, substation control centers, and computer room. The utility tunnels will be provided with a portable dry type extinguishing system.

The fire control plan will be operational prior to start-up of commercial facilities. A fire truck and mobile, dry-chemical equipment will be available for fire protection during the construction period.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.15 Health and Safety

TABLE OF CONTENTS

LIST OF TABLES

6.15 Health and Safety

The mine and processing facilities for the C-b Tract, as in any complex industrial operation, involve a variety of potential health and safety hazards. Cathedral Bluffs is committed to the highest standards of protection for the public and all CB employees, and health, safety,and security considerations are given the highest priority. To this end, a plan has been developed to (1) identify the activities and conditions that pose potential health, safety, or security risks; (2) assure compliance with the applicable lease terms, laws, and regulations; and (3) set forth the methods to mitigate health and safety hazards.

All appropriate technology will be used to ensure that sound industrial hygiene practices are incorporated and followed. Although all risks cannot be completely eliminated, CB will provide and maintain working conditions which are as safe and healthful as modern state-of-the-art safety and industrial hygiene practice can provide. A comprehensive health, safety, and security program will be developed and implemented to ensure that these objectives are achieved.

6.15.1 Activities with Potential to Affect Health and Safety

The mining of oil shale and production of shale oil poses a multiplicity of potential risks to humans. The health and safety program addresses employees as well as the public which includes visitors, trespassers, and the public at large.

Some of the compounds used in and produced by the various processes are potential health risks. Health hazards associated with mining include exposure to diesel emissions, oil shale dust containing silica and possibly other trace elements, noise, heat and cold, and high altitude. The concerns with retorting and processing are potential exposure to a number of hydrocarbons and inorganic gases, trace elements (e.g., vanadium, arsenic, nickel, and cobalt), and shale oil specific compounds.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.15 Health and Safety

Accidents are of concern particularly with the operation of equipment, tools, and machinery; the presence of dangerous compounds and materials; and the development and operation of a mine involving typical mining hazards. Above ground hazards include fires, heat (particularly hot liquids), electrocution, explosions, and so forth.

6.15.2 Regulations and Permits

6.15.2.1 Requirements

Section 5 of the Oil Shale Lease Environmental Stipulations, specifies that Cathedral Bluffs shall comply with federal health and safety laws and regulations and that

> The Lessee shall take all measures necessary to protect the health and safety of all persons affected by its activities and operations and shall immediately abate any activity or condition which threatens the life of any person or which threatens any person with bodily harm.

Cathedral Bluffs is subject to all health and safety standards applicable to metal and nonmetal mining activities mandated by the Mine Safety and Health Act (MSHA) of 1977 and the regulations promulgated under it (contained in 30 Code of Federal Regulations). For surface retorting and processing activities over which MSHA will not have jurisdiction, CB is subject to applicable regulations promulgated under the Occupational Safety and Health Act (OSHA). In addition, the Colorado mining laws and safety and health rules and regulations, as published in Bulletin 20 and enforced by the Colorado Division of Mines, will be followed. The most salient regulations are enumerated in Tables 6.1-1 and 6.1-2.

6.15.2.2 Status

The most immediately necessary health and safety permits, approvals, and petitions are listed in Table 6.15-1. All of these standards are currently undergoing revision. The acquisition of health and safety permits has not and is not expected to cause project delays.

It is expected that when the revised MSHA health regulations are issued in the mid-to-late 1980's they will be based on current and more stringent OSHA regulations. The CB occupational health program has therefore been developed to comply with both the OSHA and MSHA regulations to minimize the potential impact of any revised MSHA regulations.

The Federal Mine Safety and Health Act of 1977 provides a mechanism by which the operator or a representative of the miners may petition for a modification of any mandatory safety standard on the conditions that an alternate method of providing the same degree of protection is afforded or that a diminution of safety protection for the miners will not result. MSHA has always recognized that many of the standards it promulgates are general statements of good safety practices and cannot be applied to all underground mines because of the numerous types of mines and mining methods. As a result, MSHA will grant variances or modifications of its standards, providing that adequate safety protection is provided.

When a particular regulation is inappropriate to the CB operations, CB will seek modification from MSHA or OSHA in accordance with prescribed procedures. In many instances, specific regulatory standards applicable to oil shale industry hazards may not be developed until after the technology is commercially practiced. In these instances, best available technology or management practice will be used to minimize hazards. Cathedral Bluffs plans to provide advice and assistance to

TABLE 6.15-1

Health and Safety Petition Status Report

Petition Title	Purpose	Standard	Agency	Petition No.	Date Needed	Date of Draft	Submitted	Approved	Date of Expir.	Department	Remarks
Explosive Above Ground	Explosive storage	843 59-28	BATF CBM		02/85				(3 yrs)	H/S/S	Secretary Permit - Commissioner of Mines
Explosive Underground	Explosive storage underground (UG)	59-32, 33	DBM		06/85					H/S/S	Permit - Commissioner of Mines
Non-permissible Explosives	Use of non-permissible explosives UG	57.21-05, 96	MSHA		02/86					H/S/S	Permit - Commissioner of Mines
Flammable Liquids	Storage of flammable liquids UG	66-5	CBM		08/85					H/S/S	Permit - Commissioner of Mines
Diesel Equipment Underground	Use of diesel equipment UG	43-2	CBM		02/85					H/S/S	Permit - Commissioner of Mines
Hoist Speed	>800 ft/min hoist speed	86-12	CBM		06/85					H/S/S	Permit - Commissioner of Mines
Temp. Equip.	Field mod. of permissible equipment	57.21-78	MSHA		As Req.					H/S/S	Appv'd Dist. Mgr.
Fire Door	Fire door location	57.4-61(a)	MSHA		06/86					H/S/S	Appv'd Dist. Mgr.
Retort	Ignite retort fire underground	57.4-58	MSHA		06/01/89	11/05/81	12/10/81			H/S/S	Petition for modification mtg. to be held prior to startup

the appropriate agencies and to participate actively in rule-makings to assure the development of complete and reasonable regulations. For example, MSHA is currently revising the mine safety regulations, and CB is participating in that effort.

Because of the unique requirements of MIS retorting, CB has submitted petitions for modification to the "open flame" standard contained in 30 CFR §57.4-58 and the Gassy Mines Standards, 30 CFR §57.21 et seq.

6.15.2.2.1 Open Flame Standard

Cathedral Bluffs believes that its petition for modification of the open flame standard will be approved by MSHA in substantially the same form as filed. Occidental has operated eight MIS retorts at the Logan Wash demonstration project under close MSHA scrutiny. On October 22, 1981, MSHA granted the Logan Wash project interim relief, followed shortly by petition approval in connection with Occidental's Petition for Modification of the open flame standard (Docket No. M-81-19-M) for the simultaneous operation of two commercial-scale retorts, on substantially the same conditions as the current Petition for Modification at Cathedral Bluffs. MSHA has also granted a Petition for Modification of Standard 57.4-58 on similar conditions to the Rio Blanco Oil Shale Company, Docket No. M-78031-M (July 15, 1980). Rio Blanco used Occidental's MIS technology and its mine has been declared gassy by MSHA. Accordingly, its modification is clearly analagous to the situation at C-b. For these reasons, CB is confident that it can reach agreement with MSHA on alternative methods of compliance with the open flame standard.

It presently appears likely that before CB requires approval of its petition for modification of the open flame standard, MSHA will promulgate a standard that will allow and regulate the operation of MIS retorts. Preliminary review of a draft of that standard indicates that CB will have no difficulty in complying with its requirements.

6.15 Health and Safety

In considering the operation of MIS retorts at Logan Wash, the Colorado Division of Mines and MSHA personnel reviewed the detailed mine layout, retort location relative to working areas, bulkhead and other designs related to gas containment, availability of alternative escape routes in case of failure of any part of the system, mine ventilation, dilution effects resulting from gas leakage into ventilated areas, the overall pressure balance between the retort and the mining areas, various monitoring processes to detect leakage, and emergency plans. The operating authority contains detailed requirements for facilities design and installation, monitoring, maintenance of adequate records, and personnel training. The operations were carefully inspected by MSHA personnel before, during, and after retorting, and all operating conditions were met and no hazardous conditions had arisen.

6.15.2.2.2 Gassy Mine Standards

On January 2, 1980, MSHA declared underground operations at C-b Tract "gassy". CB is in compliance with all currently applicable gassy mines standards.

The gassy mines standards are presently undergoing review and revision by MSHA and it is anticipated that after public input into the rule-making process, new and more workable standards will result. This should reduce the number of petitions for modification previously projected.

Present standard 57.21-78 requires that only "permissible" equipment shall be used in areas of the mine where dangerous quantities of flammable gas may be present. ("Permissible" is generally defined as meaning a completely assembled product or piece of equipment which conforms with a design formally approved by MSHA as being safe to use in gassy mines.) However, because permissible power systems are not presently commercially available in all large size mining equipment, MSHA has granted modifications of this standard. Permissible

components are available for some such equipment, and for other certification by MSHA is pending. Accordingly, it is reasonable to anticipate that by the time commercial operations commence, such modifications may not be necessary.

Cathedral Bluffs has worked closely with MSHA on safety issues and should other standards be found to cause difficulty, CB feels confident it can obtain the necessary modification without serious difficulty.

6.15.2.3 Governmental Coordination

Because of the scope of the CB mining effort and because the full comprehension of MSHA technical and enforcement officials is essential, a number of informal meetings have been held with these officials to describe the CB operation in detail and to assure MSHA that proper safeguards and protection are provided for the work force. To assure that officials at all levels within MSHA are confident of CB's ability to protect the workers, these meetings have been conducted with officials of the local Grand Junction MSHA Field Office, the Denver MSHA District and subdistrict offices, and the MSHA National Headquarters Office in Arlington, Virginia. Meetings have been held and site tours conducted with the Assistant Secretary of Labor - MSHA and the Assistant Secretary of Labor - OSHA to familiarize them with the Project and to assist them in determining the respective jurisdictions of their agencies.

6.15.3 Hazards and Health and Safety Plan

The overall objective of the CB Health and Safety Plan is to reduce injuries and illnesses to the minimum level practicable for employees and the on-site public. This will be accomplished in part by the following means:

- Proper design of facilities and equipment.
- Design and implementation of safe operating procedures.
- Use of protective equipment.

6.15 Health and Safety

- Training programs.
- Physical isolation of hazards.
- Hazard analysis to identify hazards at each phase of the Project and to determine the effectiveness of mitigating measures and quantify remaining risks, if any.
- Compliance with all applicable laws and regulations, including work rules issued by CB.
- Regular monitoring of all on-site activities by trained personnel to ascertain effectiveness of the plan and recommend any necessary changes.

The primary components of the Health and Safety Plan are described in the subsequent paragraphs. Specific manuals, training programs, research programs, and so forth will developed as the project proceeds. These additional materials will be made available to the OSPO after their development.

6.15.3.1 Health

Facilities at C-b Tract will be part of the first generation of commercial shale oil production operations. Facilities and procedures will be designed in accordance with appropriate standards and prudent engineering practices to address known health risks. (Programs dealing with known health risks are described at the end of this subsection.) Programs will also be established to deal with unknown risks that could be associated with new processes.

The objective of these programs will be to detect health risks through monitoring, data analysis, and cooperating in research on the effects of the work environment. Such programs have been implemented at Occidental's Logan Wash facility where experimentation on MIS has been underway for several years. The Logan Wash data base and the findings of programs at C-b Tract will provide the foundation for development of any mitigating measures found to be necessary.

6.15 Health and Safety

The CB program will include work place characterization and occupational medicine.

6.15.3.1.1 Work Place Characterization

Data from work place sampling and analysis are being collected as part of the Logan Wash industrial hygiene program and will be used to design a program to monitor chemical, physical, and ergonomic conditions at C-b Tract.

Work Place Sampling and Analysis Program - Qualitative and quantitative characterization of work place exposures are essential to any occupational health program, and the nature of C-b Tract operations will require an extensive effort in this area. The mining portion of the proposed operation is very similar to existing operations elsewhere. Work place exposure data have been generated for the MIS process and hazardous exposures have not been detected. Although the design and operation of the MIS process is not conducive to the generation of hazardous chemical vapors in the work place, an extensive characterization was performed at Logan Wash to verify that the design specifications were met.

Initial industrial hygiene evaluations will also be made on the pilot runs for the AGR technology to be used at C-b Tract.

Work place samples will be collected to develop an exposure profile for each job task. Approved methods for analyzing work place contaminants are being tested and verified, and methods that appear to be appropriate will be incorporated into the Industrial Hygiene Analytical Methods Manual. The monitoring portion of this program is described in Section 8.10.

Oil Shale Toxicology Program - One of the essential tasks in the determination of employee health risk is the identification of the toxicity of materials in the work place. Much work has been done to characterize the toxicity

of raw shale, retorted shale, process water, and shale oil. The purpose of this program is to utilize existing toxicological research data on these materials in conjunction with work place exposure measurements to aid in health risks assessment.

Oil shale materials have been tested carefully by several research laboratories (e.g., Kettering Laboratories, University of Cincinnati; Bio-Research Consultants, Inc., Cambridge, Masschusetts; and Eppley Institute for Research in Cancer and Allied Diseases,, Omaha, Nebraska; Los Alamos National Labs, Los Alamos, New Mexico) on behalf of private oil shale companies, the American Petroleum Institute, and DOE. Detailed chemical analyses were conducted to identify the presence of known or potential cancer causing substances in oil shale rock, crude shale oil and derivative products, the rock residue from processing, and the air emissions from processing equipment. In addition, experiments have been conducted with mice and hamsters to determine if concentrations of such materials or their extracts are hazardous.

Raw and retorted oil shale rock have not shown carcinogenic characteristics in these tests. Liquid shale oil has been shown to produce skin cancer in mice as have certain uniquely processed petroleum products made from conventional crude oil. When shale oil is upgraded, however, its carcinogenic potential is greatly reduced.

Benzo-α-pyrene (BaP), a natural substance which is known to cause cancer in animals and is suspected of being able to cause cancer in humans, has been detected in shale oil and its byproducts. It is also present in higher concentrations in numerous common materials such as soil, fruit, oysters, barbequed meat, oak leaves, coal, natural sediments and ordinary paving materials. Although man is continually exposed to these items in a normal environment, these exposures have not been associated with human cancer.

The animal studies concluded that normal exposures to oil shale rock by workers and the local community during processing will not present unusual toxic or cancer-causing risks. Test animals were exposed to massive amounts of small particles and dust from the native oil shale rock and from the retorted oil shale by skin contact, breathing and eating. They did not develop cancer, and no unusual or chronic toxic effects were detected. Animals painted witn raw shale oil have developed skin cancer, however, when cases were subsequently treated hygienically they did not exhibit a problem. Potential problems of this nature in humans have been satisfactorily dealt with by industry for years and can be prevented by proper equipment design and good industrial hygiene practices.

Overall, the results of these analyses and tests demonstrate that modern industrial hygiene and safety practices in a commercial oil shale retorting facility will protect workers and others from cancer-causing materials and toxicity risks. The combined results of these studies will help form the basis of specific safety and health programs for all oil shale facilities.

6.15.3.1.2 Occupational Medicine

The occupational medicine program will include the collection and analysis of data on the worker. The monitoring activities are described in Section 8.10.1 and will include the following elements.

- Preplacement exams and medical history
- Annual screening and periodic exams
- Morbidity and mortality records
- Worker registry

The major analytic portion of the occupational medicine program will be epidemiologic studies that utilize the data that are gathered as part of the employee monitoring program. Study designs and protocols are being reviewed. The privacy of CB employees will be protected throughout this program.

6.15.3.1.3 Other Health Programs

The monitoring and analysis programs will help detect health risks that are not fully understood or anticipated and will monitor the effectiveness of programs that address known risks. Programs addressing dust, noise, and potential carcinogenic risk are described below. The training programs and employee meetings described under safety in Section 6.15.3.2 are also important to the health program.

Dust - Exposure to respirable dust containing free silica is a recognized health hazard which will result in occupational silicosis. The raw shale dust that will be generated by most mining operations will contain at least some free silica in the respirable size range and therefore must be controlled. In high concentrations, such dust not only will reduce visibility but under certain conditions may also be explosive. It is expected that present MSHA standards for silica dust exposure can be met through such normal control measures as adequate ventilation, wet drilling, water sprays, and collectors or enclosures on dust generating equipment. All underground employees will be provided with approved respirators as conditions dictate. Ambient dust concentrations will be periodically monitored throughout the mine so that high concentrations can be detected and control measures be initiated rapidly.

Noise - Exposure to high noise levels for extended periods is a recognized health hazard for which mandatory OSHA and MSHA standards also have been established. Certain operations are inherently noisy. Most of the noise in such operations originates with the equipment in use and often can be reduced by design changes or by the addition of mufflers or sound insulation. Where such action fails to reduce the noise to allowable levels, personal hearing protection equipment will be provided. Noise levels and exposure times will be monitored and recorded, and hearing tests will be given periodically to all exposed employees.

6.15 Health and Safety

Carcinogenic Risk. The toxicology program will identify the presence of any carcinogenic risks associated with prolonged exposure to retorted, or processed shale oil. Nonetheless, in the underground MIS process, such material is completely sealed in the retorts at all times and is not encountered by mine personnel. Shale oil will be present only in product streams fully isolated from the underground work environment.

6.15.3.2 Safety

6.15.3.2.1 Public Safety

There are risks associated with nearly all human activities. Conditions may be particularly hazardous for those who are not familiar with the equipment and operating procedures at C-b Tract. The thrust of the public safety program is to (1) exclude people from potentially dangerous areas and (2) protect authorized visitors that must enter hazardous areas such as the mine.

Exclusion will be accomplished by signs, physical barriers, and security practices. Warning signs will be posted in hazardous areas, and when potential for accidents is greatest, physical barriers such as solid enclosures or fences will be used. For example, explosives will be kept in a secured structure. The Tract construction area will be fenced as will hazardous areas such as ponds. Security practice will include measures taken by employees to assure that hazardous areas remain inaccessible to the public (e.g., locked enclosures). More rigourous security will be provided by a security force that will maintain the guard gate at the entrance to the Tract, as well as patrol the entire site.

Contractors, inspectors, and other visitors that must access hazardous areas will be given proper safety equipment and instruction. In all cases, such visitors will be accompanied by a CB employee.

6.15.3.2.2 Occupational Safety

The occupational safety program will entail the same general means of control as the public safety program as well as the following measures.

Examinations and Tests - Monitoring for potential hazards will be accomplished in the manner set forth in Section 8.10.

Accident Frequency Analysis - Occupational injury and illness will be reported in accordance with 30 CFR, Part 50, "Notification, Investigation, Reports, and Records of Accidents, Injuries, Illnesses, Employment, and the Coal Production in Mines." The reporting requirements under Part 50 are similar to the reporting requirements under OSHA, which apply to any facilities which come under OSHA jurisdiction. In addition, accident frequency summaries are provided to the OSPO in the semi-annual data reports.

All occurrences will be categorized monthly by (1) part of body injured, (2) type of accident, and (3) agent or material involved. Inspection and instruction will be focused on areas where an increasing trend appears or where the incidence of particular accidents are disproportionate.

Health and Safety Training - The objective of the training program is to keep personnel informed about the hazards of the work environment, safe procedures, and safety equipment.

It is possible that as the oil shale industry in the area develops, cooperative training programs may be implemented to consolidate available resources and address the training needs in the area. Until this time, CB will develop its own training plans and will continue to do so until other options become available. Detailed training plans will specify instructors, location of training, description of the teaching methods and course material to be used,

class sizes, times or periods when training will be conducted, a list of task assignments for which training will be conducted, an outline of training procedures to be used in task training, and the evaluation procedures to be used in determining the effectiveness of training.

Training programs will be developed for new employees with and without experience applicable to CB operations, employees assigned to new tasks or work environments, and visitors. To the degree appropriate, the programs will provide:

- Orientation to the work environment and procedures
- Identification of hazards (explosives, electrical, etc.)
- Instruction on statutory rights
- Instruction on self-rescue respiratory devices
- Instruction on entering and leaving the mine
- Instruction on various emergency plans, for example, mine escape plan, fire fighting plan, and evacuation plan
- Periodic refresher training to update and reinforce safety awareness
- Emergency response training for selected employees
- Instruction on health plans, procedures, and measurements
- Instruction in operating procedures for new or modified machines and equipment.

Safety Committees and Meetings - Safety meetings will be held at four organizational levels.

1) An executive safety committee consisting of members of plant management will meet regularly to develop and enforce safety policy.

2) A department safety committee consisting of superintendents, department heads, and other personnel will meet regularly to review the executive committee's recommendations, review departmental safety records, and implement accident prevention measures and health and safety programs.

6.15 Health and Safety

3) An employee's safety committee consisting of representatives from each department and representative(s) of the Health, Safety, and Security Department will meet monthly to discuss health, safety and security concerns, perform spot inspections, and make recommendations.

4) Each unit crew or department (as applicable), will hold periodic safety meetings in which the findings or recommendations of the above committees will be reviewed and discussed. Previous accidents/injuries, as well as prepared safety material made available by other departments, will be reviewed. Recommendations or concerns expressed in the safety meetings will be communicated by the supervisors who are responsible for conducting the safety meetings.

Security - The objectives of the CB Security Department are to (1) identify potential risks to persons or property and formulate and implement plans to prevent or minimize injury or loss from those risks, (2) extend immediate aid and initiate control measures during emergencies, and (3) prevent unauthorized personnel from entering the site.

The objectives will be achieved by disseminating written security guidelines, hiring qualified security personnel, proper supervision, and training. Specific security measures include a full-time manned guard gate to control access to the Tract, identification cards, security fences around critical areas, and regular security patrols. Security infractions such as crimes, unexplained fires, and gross negligence will be recorded. Incident reports will be reviewed to detect trends, identify areas that need attention, and isolate specific successes.

Explosive Dust - For a number of years it has been known that under controlled laboratory conditions oil shale dust can be made to explode. However, there are no recorded instances of such an explosion having occurred under actual mine or process plant operating conditions, even though over three million tons of oil shale have been mined in Colorado alone over the past 38 years.

6.15 Health and Safety

The October 20, 1978, Interim Report of USBM Contract No. J0275001, reported that oil shale dust particle size and volatile hydrocarbon content are important factors in determining explosivity factors. A June 30, 1982, Interim Report from the same USBM contract reported that in four oil shale mines sampled, dust concentrations were found to be well below the volatile hydrocarbon concentrations necessary to propagate an explosion.

In addition, the methods used to keep methane concentrations below explosive limits will reduce concentrations of dust further. Cathedral Bluffs will continue to moniter research on explosive dust and assess the need for preventative measures.

Explosives - Another possible source of an uncontrolled explosion is the accidental detonation of explosives. The primary explosive agent planned for use in the mine is ammonium nitrate-fuel oil (ANFO) which is very stable and difficult to detonate accidently.

Normal precautions will be taken in the storage, transportion, and detonation of explosives. The principal storage of explosives and blasting materials employed in mining will be in surface magazines conforming to Bureau of Alcohol, Tabacco and Firearms and MSHA regulations and located in accordance with the current American Table of Distances for exposives storage. Delivery of explosives to surface storage will be by suppliers' trucks.

Explosives will be delivered into the mine only in quantities necessary for one day's supply. Thus, no large quantities of these potentially hazardous materials need be stored in the mine. The minor quantities that may not be consumed during a day will be stored for use the following day in an approved magazine.

Specific training programs will address the handling of explosives.

6.15 Health and Safety

Flammable and Toxic Gases - Methane (CH_4) is a common flammable gas. Methane is non-toxic but may act as a simple asphyxiant by displacing oxygen. When mixed in the range of 5% to 15% by volume in air, a flammable (explosive) and easily ignited mixture is formed. Combustion of methane in a mine atmosphere may produce toxic gases (including carbon monoxide) and an oxygen-deficient atmosphere.

Methane has been encountered in exploration bore holes on the C-b Tract and during shaft sinking operations, and detailed evaluation of these gas occurrances is part of the mine development studies.

Although the mine will be gassy, the amount of methane produced should be relatively small and readily controlled by adequate ventilation. Automatic and manual monitoring for such gas will permit the shutdown of operations and the evacuation of personnel long before its lower explosive limit is reached. All mobile equipment that will be used beyond the last open crosscut will be rated for use in gassy mines.

Toxic gases of concern include carbon monoxide (CO) and the oxides of nitrogen (NO and NO_2). Carbon monoxide is the most common of the toxic gases found in mines. It is a colorless, odorless, tasteless, and highly toxic gas produced through incomplete combustion. Carbon monoxide is also flammable, and forms flammable mixtures with air over the range of 12.5 to 74% by volume. Concentrations within this range may be formed following a mine fire or mine explosion and are extremely uncommon.

Oxides of nitrogen (NO ahd NO_2) are formed at high temperatures by diesel and gasoline engines, electrical discharges, and blasting operations. Most oxides of nitrogen are toxic because they form corrosive acids when mixed with moisture in the lungs. While the threshold limit values for these gases are rather low, they are readily detected and normally cause no difficulty as long as proper precautions are taken to dilute them as they are formed.

6.15 Health and Safety

Although hydrogen sulfide (H_2S) may be in the rock strata at C-b Tract, it has not been detected in the numerous mine atmosphere samples taken to date. A continuing sampling program will promptly alert management if H_2S is detected so that protective measures may be implemented.

The threshold limit value (TLV) adopted by 1973 American Conference of Industrial Hygienists must not be exceeded by any gases or air contaminents. As defined by MSHA and OSHA, the TLV represents the maximum concentration of gas or vapor that a human should be exposed to in an eight-hour day.

The corner stone of the explosive and toxic gas control program is monitoring and detection which is described in Section 8.10.2.

MIS Retorting - Federal and state regulations restrict the use of fires in underground mines. However, a variance to these regulations may be granted when such use is strictly controlled and adequate safety precautions are taken. In the prototype operations at Logan Wash, pyrolysis of the oil shale rubble in the underground retort chambers has been carried to completion; and the offgases therefrom have been monitored, measured, and prevented from entering the other underground workings used by mine personnel. The present mining plan is based on the experience at Logan Wash and other prototype oil shale mines.

The retorts and their products will be completely isolated from the mine atmosphere. Pressure drops across each retort will be monitored during the pre-ignition purging cycle, and any apparent leakage will be evaluated. Major

leaks that could adversely affect retorting or mining operations will be sealed, either by grouting or other means. Techniques for minimizing leakage around bulkheads have been developed. The negative pressure maintained in the retorts and their product collection system by the surface exhaust blowers also will serve to prevent offgas leakage from the system. Under these conditions, any leaks would be into, rather than out of, the retort, and the possibility of retort offgas entering the mine work areas will be remote. Nevertheless, sufficient excess mine ventilation will be provided to dilute any gas leakage to a safe level. Ventilation air flow also will be maintained at all bulkheads in the retort area to insure dilution and dispersion of any offgas leakage. Gas monitors will sample the air at strategic locations in the mine and provide a constant check on its oxygen, methane, and carbon monoxide content. Alarms will automatically sound at pre-set levels for such gases and immediate checks of the affected area will be made to determine the cause and to initiate control measures.

Ventilation - The design of the ventilation system is based on several key concepts:

- The mine ventilation system is a negative pressure system (relative to ambient) with the main exhaust fans located on the surface.

- The ventilation system is designed to meet gassy mine standards as described in MSHA Metal/Nonmetal Safety and Health standards, 30 CFR 57.21.

- The capacity of the ventilation system will be increased in accordance with the mine development schedule.

6.15 Health and Safety

The ventilation requirements were determined taking into consideration the three following factors:

- Velocity - a minimum average velocity of 60 fpm is to be maintained to promote mixing of air in the panels.

- Diesel hp - a minimum allowance of 125 cfm per brake horsepower.

- Methane dilution - sufficient air to maintain average methane concentration of less than 1% in all parts of the mine, including return airways.

A more detailed discussion including air distribution methods (including separation of retort and mine air), environmental control and ventilation system description is provided in Section 3.3.8.

Illumination - Adequate illumination is necessary to the safe, efficient operation of the Project. The OSHA standards provide that illumination must be sufficient to provide safe working conditions on all surface operations. For underground operations, MSHA requires that individual electric lamps must be carried by all persons. Mobile mining equipment will have self-contained lighting systems to illuminate the working area for safe operation. Portable flood lights may be required in the larger void excavation areas. The various shops, offices, warehouses, and other facilities on the shaft level stations will be continously illuminated by lights connected to the mine electrical power network. Emergency lighting will be automatically activated in the event of a power failuer. Pump stations and certain other facility installations throughout the mine will also be permanently lighted.

6.15 Health and Safety

Roof Falls - Roof falls can occur in underground mining, especially in bedded sedimentary deposits where large roof areas are exposed. Falls usually occur at intersections where roof spans are greatest. Roof bolting, trusses, and appropriate roof span design minimize the likelihood of falls.

Careful design and monitoring of roof behavior, especially during development mining activities, will provide an understanding of roof behavior which will enable safe operation. Equipment also will be designed to afford as much protection as possible to their operators. Any significant unplanned roof falls will be reported to MSHA immediately; their causes will be investigated and corrective measure will be taken.

Mine Floods - Massive mine water inflows are not anticipated, but test holes will be drilled ahead of the initial development headings in each new mining area until it can be assumed that none will occur. Such test holes also would drain methane gas that could occur with the groundwater or in isolated pockets in the strata.

Seismic Hazards - The area around the Tract is one of very low seismic activity. Underground mining operations are routinely carried out in areas of much greater seismic activity without any appreciable effect. Other than the possible dislodging of loose rock from the back or ribs of the underground opening, no serious mining or safety problems would be expected from a seismic event.

Mine Escapeways and Refuge Chambers - The mine will have at least two separately maintained escapeways to the surface for underground personnel. Damage to one will not lessen the effectiveness of the other. The V/E and

Service shafts, which are equipped with hoisting facilities and emergency ladderways for personnel, normally will be used for such purposes. Designated escape routes to these shafts from the various working areas in the mine will be plainly identified.

Refuge chambers equipped with life support systems will be provided during mine development when personnel access to the surface may be prevented by fire or other emergency. All underground employees will be required to carry an approved self-rescue respirator that will provide up to one hour of personal protection from carbon monoxide present in the mine atmosphere as a result of a fire. This period of protection is more than normally would be required to reach the surface or a refuge chamber.

Plant Safety Considerations - Processing and disposal of retorted shale is largely a mechanical operation involving conveyors, trucks, and other rock-handling equipment. This type of mechanical system creates potential safety hazards, including accidents related to conveyors and shop equipment, and operation of large equipment. Equipment design and operation training will stress safety. Regular operator safety meetings will be held to maintain operator awareness.

Much of the equipment in the plant complex will utilize electric power. High voltage units represent the most serious hazards. Only qualified personnel with the proper equipment will work on electrical power circuits. Rigidly enforced safety regulations, including detailed equipment lock-out procedures will apply to all electrical work.

The conveyors used throughout the operation will be equipped with instruments to detect potentially hazardous mechanical failures before they become serious. Belts and driver machinery will be protected by shields and guards as necessary, and conveyor belt covers and enclosures will reduce the

6.15 Health and Safety

chance of accidental employee contact. Service points will be situated on one side of the equipment to eliminate climbing over or under operating machinery. Walkways will be lighted and emergency stop switches will be installed on each conveyor so that it can be deactivated at any point along the entire length of the belt.

Maintenance shops will service all mobile equipment and will be designed in accordance with OSHA and MSHA specifications. Operating equipment will be properly maintained to prevent mechanical failues which might cause accidents. The equipment will be well lighted and provided with back-up alarms as necessary. Pre-use inspections will be conducted and special attention given to items such as lights, brakes, and tires which could cause accidents if they fail to operate properly. Areas will be well lighted by stationary light standards, and dust will be controlled on working surfaces.

The potential for traffic accidents will be minimized in several ways. Where possible, traffic will be controlled in one-way flow patterns with loaded and empty vehicles traveling on separate routes. Speed limits will be enforced and the amount of roadway curvature will be held to a minimum.

Mobile equipment will be provided with heated and air-conditioned or filtered-air cabs where conditions necessitate such measures. Attempts will be made in equipment design to minimize noise and operator fatigue, and operator training courses will be required prior to assignment of vehicles. Operators will be familiarized with the control, operation, and emergency procedures which should be followed in critical situations. The traffic ways and work areas will also be regularly patrolled by supervisory personnel to help reduce careless or negligent operation.

Aboveground retorting and processing of liquid and gaseous hydrocarbons will involve hazards commonly associated with the petroleum refining industry.

6.15 Health and Safety

It is anticipated that these hazards will be controlled through the use of safe operating procedures developed through many years of experience in that industry. Design will be in accordance with accepted standards, and plant operation will be in compliance with applicable OSHA regulations.

Lines which carry hot solids will be insulated and designed to confine accidental spills wherever feasible. Steam lines and hot oil and vapor lines and equipment will be insulated and clearly marked or color coded to identify the contents of the various lines in compliance with OSHA standards.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.16 Off-Tract Facilities and Corridors

TABLE OF CONTENTS

6.16 Off-Tract Facilities and Corridors

6.16.1 Activities Affecting Off-Tract Environment

Most of the off-Tract facilities required by CB have been constructed and are in operation: this includes the access road, natural gas pipeline, electrical power lines, and micowave communications facility. Off-Tract facilities will not be required for water supply; therefore, they are discussed under Alternatives. The major off-Tract facilities yet to be developed are the Rifle marshalling yard and the product pipeline.

6.16.2 Regulations and Permits

The site of the marshalling yard is properly zoned; therefore, only routine building permits will be required before construction can commence.

A preliminary right-of-way (ROW) for the product pipeline that would link the C-b Tract and Rangely has been suggested by CB. The route would traverse primarily federal lands managed by BLM. Other alternative routes proceed south from the Tract to connect with either the Union or LaSal corridors. See Section 3.8.18 for a discussion of these alternatives. Final route selection must meet the criteria of the BLM and County Corridor Committee which have the responsibility for approving ROWs.

The BLM is preparing a Resource Management Plan (RMP) for the Piceance Creek area. This will be followed by an Activity Management Plan to specify ROW corridors that will minimize potential environmental impacts and economic disruption. CB will coordinate with the BLM during the development of these plans to assure that the ROW of the product pipeline is incorporated into the planning process.

Environmental impact statements (EIS) are being prepared for other pipeline ROW's in the area: the Corps of Engineers is preparing an EIS for the Union Oil

Company, and the BLM is preparing an EIS for Chevron and Mobil. The EIS for the LaSal route has been approved. Consequently, EIS's have been, or are being prepared for all the ROW's proposed by CB.

6.16.3 Potential Effects and Mitigation

Preliminary indications are that there should be no significant environmental impacts associated with the development and operation of the marshalling yard. It is located in a developed area; it is compatible with adjacent land uses; and the activities occurring there should not affect the environment.

Construction and potential spills are the most important environmental issues associated with the pipeline. The proposed pipeline will be underground and will, therefore, have little long-term effect on the ecological environment.

The ROW will be 50 ft. wide; however, 100 ft. will be required for construction activities. Construction could potentially disrupt cultural, water, and ecological resources. Potential spills are primarily a threat to surface water and related ecology.

Potential effects will be minimized through route selection, construction techniques, system design, and maintenance. The BLM and CB will conduct route-specific environmental studies to identify environmental resources and will develop strategies to minimize impacts. There are few geographic or technical constraints that would prevent the avoidance of environmentally sensitive or hazardous areas.

During construction all practical means for minimizing impacts outside the construction zone (e.g., water erosion) will be taken. In addition, the pipeline

will be designed, constructed, and maintained in accordance with prevailing standards concerning cathodic protection, stream crossings (if any), and valving and controls.

Spills cannot be totally prevented; however, through the aforementioned measures -- proper route selection, design, construction, and maintenance -- the likelihood of occurrance and the potential extent of effects will be minimized. A Spill Prevention and Countermeasure Plan will be developed in accordance with EPA requirements and prudent planning.

6.16.4 Environmental Effects

The unavoidable consequences of pipeline construction and operation will include: (1) temporary disturbances to the ecological environment during construction, (2) the probable long-term removal of habitat along the 50-ft. wide ROW, and (3) risk and potential consequences of spills.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.17 Abandonment Plan

TABLE OF CONTENTS

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

6.17 Abandonment Plan

6.17.1 Introduction

The projected life of the Project is approximately 34 years, and it is uncertain how the facilities might be modified or whether they will continue to be used or abandoned at the end of 34 years. Upon termination of the C-b Lease, the disposition of all property on the Tract will be determined. Section 32 of the Lease dictates how the status of all "structures, equipment, machinery, tools, appliances, and materials on the leased land" will be finalized.

In accordance with the Lease requirements, C-b facilities will be decommissioned following the cessation of operations. The following plan is generalized in accordance with current acceptable decommissioning procedures. The primary objective of the plan is to assure the placement of the disturbed area back to a condition similar to the pre-activity environs. This plan does not address reclaiming the processed shale area; this topic is covered in the Reclamation Plan (Section 6.5). Also, subsidence (Section 6.9) and MIS retort-effects monitoring (Section 8.5) are covered elsewhere.

6.17.2 Abandonment

CB facilities which require abandonment procedures are as follows:

- Service and Production Shafts;
- Ventilation Shaft(s);
- Retort offgas shafts;
- Hydrological monitoring wells (if applicable);
- Staging areas;
- Mine Support Facilities;

- Access roads;
- Utility and pipeline right-of-ways;
- Substations and explosive storage areas;
- Mine water treatment ponds;
- Inpoundments;
- Injection and dewatering well sites; and
- MIS retorts.

6.17.2.1 Mine/Shafts

These major structures (e.g., headframes) will be disassembled to ground level and the shafts could be caved or capped. The potential effects on groundwater quality are being studied and monitoring will continue through the Project's life. It is possible that the underground works may be allowed to refill with water thereby creating a sizable storage facility that could service future agricultural and industrial needs. It is also possible that the underground voids would provide useful and secure waste storage. Analyses indicate that movement of the groundwater in the vicinity of the Tract is exceedingly slow; and lateral migration, if it occurs, should have no effect on quantity and quality of usable groundwater. This will be further substantiated by continued monitoring and analysis during the life of the Project. The area adjacent to the shafts will be ripped and all non-soil material will be removed to an appropriate disposal site. Following the removal of this material, the area will be prepared as a seedbed utilizing successful reclamation technology. Reclamation procedures per the existing plan (Section 6.5) will be applied to reduce wind and water erosion and to provide a self-sustaining vegetative community.

6.17 Abandonment Plan

All non-soil material which has no salvageable value will be reduced in size to pieces suitable for burial on-site. All salvageable material will be taken to staging areas for appropriate disposition.

6.17.2.2 MIS Retorts

Underground areas associated with MIS retorting will be monitored following Project completion to identify possible effects and time required to return to baseline conditions. Tests to date indicate monitoring may be required 3-5 years following cessation of retorting.

6.17.2.3 Groundwater Monitoring Wells

As some groundwater wells will be used for long-term monitoring of groundwater quality, the precise number of wells to be abandoned is uncertain and subject to long-term monitoring requirements. Those wells which are not required for monitoring will be filled with grout and/or cement; the collar will be cut-off; and the well capped per well abandonment regulations. Seed bed preparation and subsequent reclamation will be undertaken as set forth in the Reclamation Plan.

6.17.2.4 Staging Areas

All staging areas associated with the mine and MIS retorting process will be ripped and reclaimed. All non-soil related material will be removed and disposed of in a manner consistent with Lease requirements. Since this material will be classified as nontoxic, it can be disposed of in a state-approved disposal site. The areas will then be graded to a contour which blends into the surrounding environment then reclaimed in accordance with prescribed guidelines identified in the Reclamation Plan.

6.17 Abandonment Plan

6.17.2.5 Access Roads

The precise disposition of access roads into the Tract C-b area is uncertain pending review by the OSPO, BLM and private landowners. As Piceance Creek Basin is a recreational area, it may be desirable to retain the road to allow further accessibility into the western portion of the basin.

If the decision is made to remove the access roads, they will be bladed clean of foreign material. This material (e.g., asphalt) will be trucked to an off-Tract disposal site. The remaining road bed will be disked to approximately 3 inches to allow root penetration. Topsoil will then be applied. This will allow for proper seed germination following application of the seed and mulch.

6.17.2.6 Surface Facilities

The greatest visual and surface disturbance will be associated with the surface processing facilities. CB will disassemble all surface structures, and dispose of all but reclaimable materials (e.g., structural steel, vats, etc.).

Salvageable material will be cut to manageable sizes and trucked to temporary storage areas for final disposition. Other material will be disposed in an approved dumpsite. Any toxic materials will be transported to a proper disposal/recycle center.

The entire area associated with retorting will be sampled for the presence of toxic substances from the operation. Soil corings will determine the precise

contaminated areas. Contaminated soil will be removed and disposed in an approved landfill. The entire area will then be regraded to original contour and ripped to 4 inches. Topsoil will then be applied with subsequent restoration consistent with the approved Reclamation Plan.

This plan has been designed to abandonment procedures acceptable in 1983 recognizing that new or modified procedures will evolve over the life of the Project. The intent, nevertheless, is to return the site to a condition similar to that which existed before Project initiation by removing man-made materials, and by recontouring, and revegetating.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

References

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

References

Cathedral Bluffs Shale Oil Company (1982a): CB Laboratory Report B-1989. November 24, 1982.

Cathedral Bluffs Shale Oil Company (1982b): Prevention of Significant Deterioration Amendment - Permit Application to the U.S. EPA, Region VIII. December, 1982.

C-b Shale Oil Venture (1977): Environmental Baseline Program, November 1974 - October 1976, Final Report, Ashland Oil, Inc., Occidental Oil Shale, Inc., Operator.

Executive Summary. 57pp.
Volume 1 Regional and Temporal setting. 221pp.
Volume 2 Hydrology. 329 pp.
Volume 3 Meteorology, Air Quality, and Noise. 508 pp.
Volume 4 Ecology. 457 pp.
Volume 4 Ecology Appendices A & B. 509 pp.
Volume 5 System Interrelationships. 249 pp.
Volume 5 System Interrelationships, Appendix F. User's Reference Diagrams. Unpaged.

Dvorak, A. J. et al (1978): "Impacts of Coal-Fired Power Plants on Fish, Wildlife and Their Habitats". USDI, FWS, OBS - 1978, Vol. 29.

EPA (1980): Workbook for Estimating Visibility Impairment, U. S. Environmental Protection Agency, Research Triangle Park, N.C. July, 1980.

Ferenbaugh, N. W. (1978): "Effects of Long Exposure of *Oryzopsis hymenoides* to SO_2". Water, Air and Soil Pollution. Vol. 10, pp. 27-31.

Fox, D. (1982): A Suggested Methodology for Estimating Atmospheric Deposition Within 200 km of Isolated Sources in Clean Areas. Unpublished.

6.0 ENVIRONMENTAL EFFECTS AND CONTROL PLANS

References

Heck, W. W. and C. S. Brandt (1977): "Effects on Vegetation: Native Crops, Forests," in Stern, A. C. (ed). Air Pollution, third edition, Vol. II. The Effects of Air Pollution. Academic Press, NY.

Hill, A. C., S. Hill, C. Lamb, and T. W. Barrett (1974): "Sensitivity of Native Desert Vegetation to SO_2 and to SO_2 and NO_2 Combined." JAPCA, Vol. 24, No. 2, pp. 153-157.

Howard, E. A., et al (1980): Bibliography of Air Quality Effects on Natural Ecosystems. USDI, NPS, (unpublished).

McFee. William W. (1980): "Sensitivity of Soil Regions to Long Term Acid Precipitation", in Atmospheric Sulfur Deposition by Shriner, Richmond and Lindley. Ann Arbor Science, Chapter 48, pp. 495-505.

Montana Dept. of Health and Environmental Sciences (1979): Environmental Impact Statement - Montana Ambient Air Quality Standards Study.

Newman, J. R. (1980): Effects of Air Emissions on Wildlife Resources. USDI Fish and Wildlife Service, Office of Biological Services, National Power Plant Team.

Piceance Basin Wildlife Habitat Management Plan (1982). Issued jointly by Colorado Division of Wildlife and BLM, Meeker.

Roth, P. M., M. A. Yocke, J. P. Meyer, M. F. Liu, and J. P. Killus (1975): An Examination of the Accuracy and Adequacy of Air Quality Models and Monitoring Data for Use in Assessing the Impact of EPA Significant Deteoriation Regulations on Energy Developments, SAI Inc. Prepared for Greenfield, Attaway and Tyler, Inc. Under Prime Contract to API., August 8, 1975.

Synthetic Fuels Corporation (1983), "Interim Environmental Monitoring Plan Guidelines." Federal Register, Vol.48, No. 64/Friday, April 1, 1983/Notices pp 14108-14113.

References

Thompson, C. R., G. Kats, and R. W. Lennox (1980): "Effects of SO_2 and/or NO_2 on Native Plants of the Mojave Desert and Eastern Mojave-Colorado Desert." JAPCA, Vol. 30, No. 12, pp. 1304-1309.

Wagner, E. J. and P. L. Wanek (1981): An Assessment and Control of Water Contamination Associated with Shale Oil Extraction and Processing, LASL 9084-PR. March, 1981.

Woodward-Clyde Consultants (1983): Retorted Shale Disposal Area, Cathedral Bluffs Shale Oil Project, C-b Tract, Rio Blanco County, Colorado. Contract No. CB-13-83. May, 1983.

TABLE OF CONTENTS

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

7.0 SOCIOECONOMIC AND TRANSPORTATION

7.1 Description of Current Conditions

Cathedral Bluffs is committed to the mitigation of adverse socio-economic impacts associated with its activities. Ongoing mitigation is expected to be accomplished through a Major Development Permit negotiated with Rio Blanco County which will incorporate needs within neighboring Garfield County as well. This agreement will recognize the current excess capacity of community infrastructure and the availability of Oil Shale Trust Funds, which were originally provided in part by CB.

The socioeconomic impacts of the Project will focus primarily upon communities in western Garfield County and eastern Rio Blanco County (See Figure 7.1-1). The majority of permanent CB workers (75%) are expected to reside in Garfield County, primarily in the community of Rifle and the balance (25%) are expected to reside in Rio Blanco County.

The expected residential distribution of CB employees is based on actual residency patterns observed in the course of monitoring programs which have continued since 1978. Monitoring data were reported at quarterly to semi-annual intervals from June 1978 to January 1982.

The information which follows includes an analysis of current socio-economic conditions and an assessment of the anticipated impacts of CB development. Mitigation of impacts as well as the interaction of CB management with state and local officials in developing specific mitigation plans is discussed.

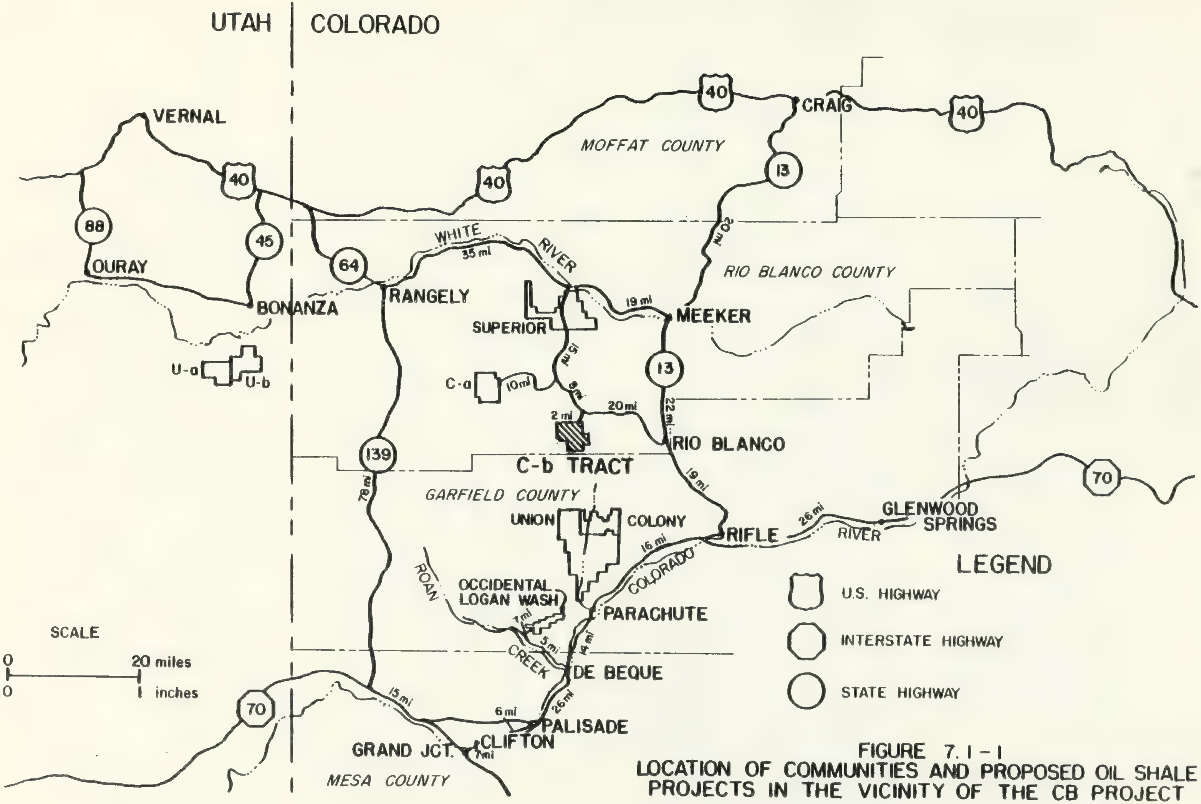


FIGURE 7.1-1
LOCATION OF COMMUNITIES AND PROPOSED OIL SHALE PROJECTS IN THE VICINITY OF THE CB PROJECT

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

Because of their relative locations with respect to oil shale and other energy resources, area communities have anticipated rapid population growth since the early 1970's. However, due to delays in the development schedules of various energy projects, growth rates have been generally moderate in recent years. Local governments have had an opportunity to expand public services and excess capacity exists at present.

A number of jurisdictions will be affected by the development of the Project; these include counties, municipalities, school districts and special purpose districts. The C-b Tract lies within Rio Blanco County and the Meeker RE-1 School District. Employees and related population will reside in Garfield County, the towns of Meeker, Rifle, Silt and Parachute, Garfield School District RE-2 and Grand Valley School District #16. The sanitation district in Meeker, the Rifle hospital district, and various other special purpose districts will also be affected.

7.1.1 Employment and Population

The Colorado economy as a whole has suffered from the slowdown in mining and oil and gas industries over recent years. Statewide unemployment stood at 7.3% in June, 1983, representing about 122,000 persons. In occupations most closely associated with the oil shale industry, mining and construction, total employment decreased significantly in 1982. Statewide employment in mining occupations fell from 46,200 to 40,700, while employment in construction occupations fell from 82,100 to 78,100 during 1982.

Western Colorado, an area which has experienced rapid growth in employment in recent years, and which has a normally low unemployment rate has been particularly affected by the economic slowdown. The shutdown of the Colony Oil Shale Project in May 1982 eliminated 2,100 jobs, primarily in the construction trades. Nearly 2,000 molybdenum miners and mill employees have been on temporary layoffs in recent months, and many of these jobs are expected to be permanently lost. Colorado coal mines, mostly in the western part of the state, have laid

off more than 600 miners due to a sagging market. Garfield and Rio Blanco Counties are now experiencing unemployment rates which are higher than the state as a whole and significantly higher than either county has experienced in the past.

Rio Blanco County has an estimated labor force of 4,330 of which 416 persons or 9.6% are estimated to be unemployed. Garfield County's labor force numbers 19,620 persons of which an estimated 2,234 or 11.4% are unemployed (Source: Colorado Labor Force Estimates, Colorado Division of Employment and Training, August, 1983).

The Colorado Division of Employment and Training tracks regional labor supply and demand data on a quarterly basis. The most recent Quarterly Occupational Supply/Demand Outlook (second quarter 1983) indicates that many of the occupations required by CB are currently oversupplied in western Colorado. The Division's data indicate that welders, electricians, electrician helpers, bulldozer operators, operating engineers, pipefitters, industrial truck operators and miners are either "highly oversupplied" or "significantly oversupplied" in western Colorado.

A breakdown of employment by industry is shown in Table 7.1-1. Employment in Garfield County is concentrated in wholesale and retail trade, construction, independent proprietors, government, and services. Mining and government are the major employers in Rio Blanco County. The majority of current mining employment is associated with oil and gas exploration.

Future employment and population growth in Garfield and Rio Blanco Counties is highly dependent upon the development of the area's energy resources. In forecasting future trends, CB has utilized the Planning and Assessment System (PAS) Model developed through the efforts of an organization of local, state, federal, and industry interests collectively referred to as the Cumulative Impacts Task Force (CITF). The CITF was established in an effort to develop a means to analyze the cumulative effects of energy development and basic

TABLE 7.1-1 Employment by Industry Sector for the State of Colorado, Garfield, and Rio Blanco Counties*

Industry	Colorado Total		Garfield County		Rio Blanco County	
	Total Employment	%	Total Employment	%	Total Employment	%
Mining	40,100	3	140	1	1,430	40
Construction	72,500	5	2,061	16	214	6
Manufacturing	177,700	12	246	2	36	1
Transportation, Utilities	80,200	6	939	8	290	8
Wholesale & Retail Trade	314,700	22	2,826	22	282	8
Finance, Insurance, Real Estate	81,700	6	535	4	40	1
Services	272,300	19	2,104	16	140	4
Government	237,800	17	2,098	16	607	17
Indp. Proprietors & Other	156,800	11	1,934	15	536	15
Total	1,433,100	100	12,883	100	3,575	100

*Agricultural employment is not included in these figures.
Source: Cathedral Bluffs Estimate, using the Planning and Assessment System Model.

economic activities within a six county region of western Colorado. The PAS Model and related assessment techniques developed in the course of CITF work during 1981-82 have been utilized in the socioeconomic evaluation by CB. Complete details of the various model inputs are available for inspection at CB's Grand Junction offices, and are not included here.

Baseline (i.e., most likely socioeconomic conditions excluding CB) employment and population projections displayed in Tables 7.1-2 and 7.1-3 indicate that Garfield County is expected to lose employment and population through 1986, and then to increase again to a population peak of 29,530 in 2000. By comparison, Rio Blanco County employment and population is expected to increase at a modest rate throughout the projection period.

The baseline projections reflect CB's judgment as to the level of employment in the various economic sectors. Oil shale development is represented by the Union Oil Parachute Creek Project. Other shale projects were omitted because there are no firm publicly announced plans for development.

The employment and corresponding population peaks in Garfield County in 1982 are due to an expected drop in construction employment from a 1982 high of 3,134, to 1,146 by 1986. Most of the decrease is directly associated with the shutdown of the Colony Project and completion of the first phase of construction on the Union Parachute Creek facility. With the beginning of Union's operations in 1983, about 250 jobs were created in the mining sector. The rate of employment and population growth in Garfield County may increase in 1985-86 if the proposed second phase of the Union Project is implemented.

A similar situation is expected in Rio Blanco County as construction is completed on the Desarado Coal Mine and Moon Lake Power Project in 1983. Construction sector employment is expected to decrease from a peak of 1,007 in 1983, to 427 by 1986. About 300 of the construction jobs are expected to be replaced by employment in the mining sector.

TABLE 7.1-2 Baseline Case Employment Projections 1983 - 2000

Year	Total Employment Garfield County	 Rio Blanco County
1983	12,880	3,580
1984	13,170	3,650
1985	12,960	3,760
1986	12,790	3,860
1987	12,810	3,930
1988	12,920	3,980
1989	13,050	4,020
1990	13,190	4,110
1995	13,710	4,310
2000	14,280	4,480

Source: Cathedral Bluffs Estimate, Using the Planning Assessment System Model (October, 1983).

TABLE 7.1-3 Baseline Case Population Projections 1983 - 2000

Year	Garfield County Total	Garfield County Rifle	Garfield County Silt	Rio Blanco County Total	Rio Blanco County Meeker
1983	28,530	4,630	1,060	7,300	2,450
1984	28,390	4,550	1,050	7,650	2,480
1985	28,230	4,510	1,030	7,720	2,510
1986	28,050	4,500	1,030	7,940	2,580
1987	28,120	4,500	1,030	8,350	2,710
1988	28,320	4,530	1,040	8,470	2,750
1989	28,500	4,550	1,040	8,600	2,800
1990	28,660	4,580	1,050	8,800	2,860
1995	29,230	4,670	1,070	9,220	3,000
2000	29,530	4,720	1,080	9,460	3,070

Source: Cathedral Bluffs Estimate, Using the Planning Assessment System Model (October, 1983).

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

7.1.2 Public Services and Facilities

The counties and communities in the Project area have upgraded their services and facilities. The facility improvements and expansions give the counties and the communities of Rifle, Meeker, and Silt a capacity to accommodate substantial growth. The vast majority of this upgrading was accomplished with assistance from the State Oil Shale Trust Fund. The Fund was established using the 37.5% component of the bonus bids on federal lease Tracts C-a and C-b which was returned to the state under terms of the Mineral Leasing Act.

7.1.2.1 Garfield County

Garfield County is in the process of constructing a major addition to its courthouse building which will accommodate most county services in a single building. The county is also planning to construct a new and expanded jail facility. A new building complex to house human service agencies in Rifle is scheduled for construction in 1983. This facility will provide space for the Garfield County Department of Social Services, Sopris Mental Health Center, Garfield Youth Services, Mountain Valley Development Preschool, Garfield County Public Health Nursing, Rocky Mountain Planned Parenthood and Grand River Hospice. In addition, Garfield County's human service programs have been bolstered through the hiring of a Human Services Coordinator, and the receipt of block-grant funds from the state. A Garfield County United Way has recently been formed and it will contribute additional funds to support human services.

The county has significantly expanded its law enforcement staff to provide for anticipated population growth through the early 1980's. The county intends to try to maintain its expanded law enforcement staff notwithstanding the uncertainties of oil shale development.

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

7.1.2.2 Rifle

Rifle (1983 estimated population 4,630) has recently completed a major expansion of its municipal water system providing the capacity to serve 10,000 persons. The new water system was also designed for further population growth. The addition of a filtering unit to the plant and other minor improvements will give the water treatment plant the capacity to provide for 16,000 residents.

The municipal sewage treatment system in Rifle has also been expanded, with the construction of a major outfall line and upgrading of the treatment lagoon. The sewage treatment system now has a design capacity for about 10,000 persons.

Law enforcement services in Rifle are continually being upgraded. The police force now includes twelve full-time officers, which exceeds the state standard of two officers per 1,000 persons. Fire protection is managed by a special district, separate from the municipal government, and it has also kept pace with the growing demand for service.

Rifle recently completed a major remodeling of the city hall and construction of a new municipal complex is underway. The complex will house all municipal offices and is scheduled for construction in 1983. Plans are also being finalized for new public recreation facilities, including a 30,000 - 35,000 sq. ft indoor recreation complex. These projects are to be financed through the Oil Shale Trust Fund.

Clagett Memorial Hospital serves the communities of Rifle and Silt, as well as Parachute and New Castle. The facility has 32 beds and is currently operating at an average occupancy rate of 40%. Outpatient service requirements have grown in recent years, and the hospital district recently completed the construction of a new emergency room, laboratory and x-ray facilities. The additional capacity for outpatient services and the existing low level of utilization will allow for substantial increases in patient loading.

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

In addition to Clagett Memorial Hospital, Valley View Hospital in Glenwood Springs, 26 miles away, and St. Mary's Hospital in Grand Junction, 65 miles away, serve Rifle. Valley View currently is a 50 bed hospital with 54 physicians on staff. An expansion program is underway which will increase the capacity of the hospital to 80 beds and offer expanded services in the areas of surgery, critical care and obstetrics. This expansion program at Valley View Hospital will add 30,000 to 50,000 sq. ft of space at a cost of over $4 million.

St. Mary's Hospital is the largest medical center between Denver and Salt Lake City. St. Mary's has a current capacity of 222 beds and offers complete health care services. St. Mary's has 70 physicians on its medical staff, including more than 30 specialists. St. Mary's services a wide area and offers emergency helicopter ambulance service to persons in remote locales. St. Mary's is currently undergoing a major expansion program which will add 40 beds and substantially upgrade its critical care services, at an estimated cost of $22 million.

Rifle is planning and managing its growth and development within the guidelines of a comprehensive land use plan completed two years ago. Development of the plan was supported by a contribution from CB. The plan identifies specific land and facility requirements for municipal expansion to a population of 25,000 persons.

7.1.2.3 Silt

The town of Silt (1983 estimated population 1,060) has completed an upgrading and expansion of its water system which will accommodate some 2,800 persons, or more than double the existing population. An expansion program is underway on the sewage treatment system to provide advanced treatment capacity for the same number of persons.

Silt has recently completed a new town hall with funds available from the Oil Shale Trust Fund. The facility houses the police and fire departments, as well as providing greatly expanded space for administrative offices.

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

The town recently completed a land use planning program which contains specific guidelines for accommodating future growth and development.

7.1.2.4 Rio Blanco County

Rio Blanco County has established a capital improvements fund using its share of the 1981 Oil Share Trust Fund appropriation. Initially, the fund contained over $16 million and with interest now totals over $19 million. The county desires to preserve the principal of the fund until it is needed to support public facility and service development.

Most of the facility and service expansion in Rio Blanco County is centered in the western portion of the county. This area is being affected by coal development, and is not expected to be directly affected by development of the CB Project.

7.1.2.5 Meeker

Meeker (1983 estimated population of 2,450) is completing a major expansion of its municipal water system. Once this expansion is completed, the system will have the capacity of 6,500 persons. The Meeker sanitation district is also upgrading its sewage treatment system to a capacity of 8,000 persons.

Law enforcement and fire protection services have expanded as necessary to accommodate growth. Meeker has added personnel to its police force in recent years to keep pace with law enforcement demands. The Meeker fire department has upgraded its capabilities and has a modern fleet of fire fighting equipment.

Plans are being developed for relocation of the city offices to a civic center complex, at which time the present city hall building will be made available to the fire department. The civic center complex will provide space

for future expansion of all county and municipal administrative services in Meeker. Plans are also being finalized for new recreation facilities, including a softball complex and a skating rink.

Pioneer Hospital in Meeker is a 17-bed facility, which includes a nursing home. The greatest increase in demand for medical services in Rifle and Meeker in recent years has been for outpatient services. Pioneer Hospital has just completed a major expansion program that included major equipment additions and the construction of a new emergency room, trauma room, and administrative and laboratory facilities. A planning program has been initiated and a consulting firm retained to identify additional services needed.

The town of Meeker is engaged in developing a comprehensive planning program. Cathedral Bluffs has been a principal sponsor and financial contributor to the effort. The program includes the development of planning objectives; land use, housing and facility planning elements; revisions to existing zoning and subdivision regulations; and intergovernmental agreements. In addition, CB financed the preparation of a parks and recreation master plan for the Meeker area which identifies recreation facilities required to provide for projected growth.

7.1.3 Public Education

Current enrollment and design capacity of the two school districts which serve the communities of Rifle, Meeker, and Silt is displayed in Table 7.1-4.

Garfield County School District RE-2 operates three elementary schools, a combination elementary-junior high school, a junior high school, and a senior high school. These facilities serve the communities of Rifle, Silt, and New Castle.

TABLE 7.1-4

School District Enrollment and Facility Capacity - 1982

School District	Enrollment	Current Design Capacity
Garfield School District RE-2		
Elementary	1,203	1,350
Junior High	500	485
Senior High	601	660
Total	2,304	2,495
Meeker School District RE-1		
Elementary	455	375
Junior High	142	390
Senior High	265	505
Total	862	1,270

Source: RE-2 School District, September 1982
RE-1 School District, October 1982
Colorado Cumulative Impacts Task Force, October 1982

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

Schools in the Garfield RE-2 District are currently operating near capacity, even though a new high school and a new elementary school have recently been completed. The district has over $7 million for school expansion available from the Oil Shale Trust Fund. These monies will be used to add 6,000 sq. ft. to the new elementary school in Rifle, increasing its capacity from 350 students to 525 students. A vocational center for Rifle High School will increase capacity to about 800 students. A new junior/senior high school, a new elementary school, and construction of new shop facilities and administrative offices can be accomplished with available funds. As discussed later, these facilities should allow the district to keep pace with enrollment increases over the next several years.

School programs in the RE-2 District have been upgraded in recent years as a result of growth. Salaries have been increased for both certified and non-certified personnel. The pupil-teacher ratio in the district is 17.4 to 1. This favorable ratio allows for both a productive and pleasant educational environment according to school district officials. Recent staff additions include a full time psychologist and two new student specialists. School enrollment in Rifle has remained stable over the past year in spite of the overall decrease in employment and population in the area. School District enrollment growth in Meeker has been much slower, consequently Meeker currently has excess capacity.

School District RE-1 has recently completed a land trade of 24 acres with the City of Meeker for two future school sites. A total of nine additional sites is proposed within the Meeker Terraces housing development east of the city. The district proposes to use money from the Oil Shale Trust Fund to construct a kindergarten building, a new elementary school, and a major addition to the junior high school as required by enrollment growth.

School District RE-1 has a student-teacher ratio of 25 to 1. It hopes to reduce that ratio in future years when sufficient revenues become available.

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

A projection of school age population for baseline or trend growth is shown in Table 7.1-5. The data do not correspond exactly to current enrollment because the model assumes that all children in the projected 5 to 18 year age group attend public school within the district. Nonetheless, the projections indicate that neither school district should be subject to overcrowding in the near future.

7.1.4 Housing

7.1.4.1 Rifle

The city of Rifle estimates that a total of 2,137 residential housing units exist within that community. Of these, an estimated 1,052 are single family houses, 116 are duplexes, 620 are mutli-family apartments or townhouses, and 349 are mobile home spaces. Of the total, 145 units, or 7% were estimated to be vacant as of April, 1983. The highest proportion of vacancies existed in multi-family housing where 14% of the units were reported vacant.

Rifle issued a record high of 544 residential building permits in 1981. Since then, residential construction has fallen dramatically. Prior to 1981, Rifle issued about 120 permits for residential construction annually.

The city of Rifle estimates that there are over 3,800 dwelling units which have received all necessary approval for construction at the present time. Additional units have been proposed and are in various stages of the approval process, including the La Mesa development, which contains almost 2,000 acres and would accommodate 7,000 units.

7.1.4.2 Silt

Silt has also experienced a slowdown in new home construction. The average annual number of residential building permits issued in Silt in recent years is

TABLE 7.1-5

Baseline Case - Projected School Age Population 1983 - 2000*
(Ages 5 Years - 18 Years)

Year	Garfield County District RE-2	Meeker School District RE-1
1983	2,050	892
1984	2,130	900
1985	2,160	920
1986	2,190	940
1987	2,220	970
1988	2,250	990
1989	2,280	1,010
1990	2,300	1,010
1995	2,290	1,020
2000	2,060	970

Source: Cathedral Bluffs Estimate, Using the Planning Assessment System Model (October, 1983).

*The 1982 School District design capacity for Garfield County District RE-2 was 2,495; for the Meeker School District RE-1, 1,270.

about 35. Silt has three large subdivisions which have received approval for development. Once developed, these subdivisions would contain 170 residential units.

The expected 1983 - 2000 demand for total housing units in the communities of Rifle, Meeker, and Silt is shown in Table 7.1-6. Sufficient housing should be available through existing and approved development to provide for the indicated demand at normal construction rates.

7.1.4.3 Meeker

Rio Blanco County estimates that there are currently 1,023 residential housing units in Meeker. Of these, 701 are single family houses, 206 are apartment units and 116 are mobile home spaces. As of April, 1983, an estimated 114 units or 11% of the total were vacant. The largest proportion of vacancies existed in apartment housing where 47% of the units were reported vacant. Only 12 single family houses and four mobile home spaces were reported vacant.

The number of building permits issued in Meeker has declined in 1983. Prior to 1981, Meeker issued approximately 40 residential building permits per year.

In Meeker, two major residential subdivisions, which contain space for over 300 housing units, are in the initial stages of development. Another major development containing over 1,400 acres is proposed east of Meeker. This development could include up to 5,000 housing units.

7.1.5 Transportation

The principal access to the C-b Tract is by the Piceance Creek Road from either Colorado Highway 13 or Colorado Highway 64. All of the routes are paved, two-lane highways, maintained by the State of Colorado, or in the case of the Piceance Creek Road, by Rio Blanco County.

TABLE 7.1-6

Baseline Case - Projected Housing Demand*
1983 - 2000

	Total Units		
Year	Rifle	Meeker	Silt
1983	1,840	930	420
1984	1,840	950	410
1985	1,800	970	410
1986	1,800	1,020	410
1987	1,800	1,040	410
1988	1,810	1,060	410
1989	1,820	1,080	420
1990	1,830	1,080	420
1995	1,870	1,130	430
2000	1,890	1,160	430

Source: Cathedral Bluffs Estimate, Using the Planning Assessment System Model (October, 1983).

*Estimates of total units available and approved for construction are: Rifle, 5,940; Meeker, 1,320; and Silt, 670.

7.0 SOCIOECONOMICS

7.1 Description of Current Conditions

Figure 7.1-2 indicates the Average Daily Traffic (ADT) volume along these roadways in 1978 and in 1980.

The Colorado Highway Department has established general highway design capacity of 900 vehicles per hour (VPH) for two-lane highways at vehicle operating speeds of 52-57 M.P.H. (Colorado Highway Department Design Manual, January, 1972). To apply this criterion to Highways 13 and 64 and the Piceance Creek Road, the Highway Department suggests an adjustment for rolling terrain and percentage of large trucks using the roadway. For the purposes of this analysis, an adjustment factor of 0.5 was used, giving these roadways an approximate design capacity of 450 VPH. Using the Highway Department conversion factor of 0.14 (ADT) = VPH, the approximate equivalent capacity for these highways is 3,215 ADT.

Railroad access is provided to the area by the D&RGW Railroad, which links Denver and Salt Lake City through Rifle. Cathedral Bluffs owns 40 acres of property along the D&RGW tracks west of Rifle. Plans call for the eventual construction of a railroad load-out facility on that property.

Commercial air service has been provided to the Garfield County Airport in Rifle and is available at Walker Field in Grand Junction.

The growth in demand upon the regional transportation system is not easily estimated. There is a general correlation between transportation usage and population, so the projected growth rate in Rio Blanco County population was applied to the traffic volumes along local highways to estimate 1990 and 2000 levels of traffic volume. These figures are displayed in Figure 7.1-3. Projections indicate that growth in traffic volume should not exceed roadway design capacity on any of the road segments in the Project area through the year 2000.

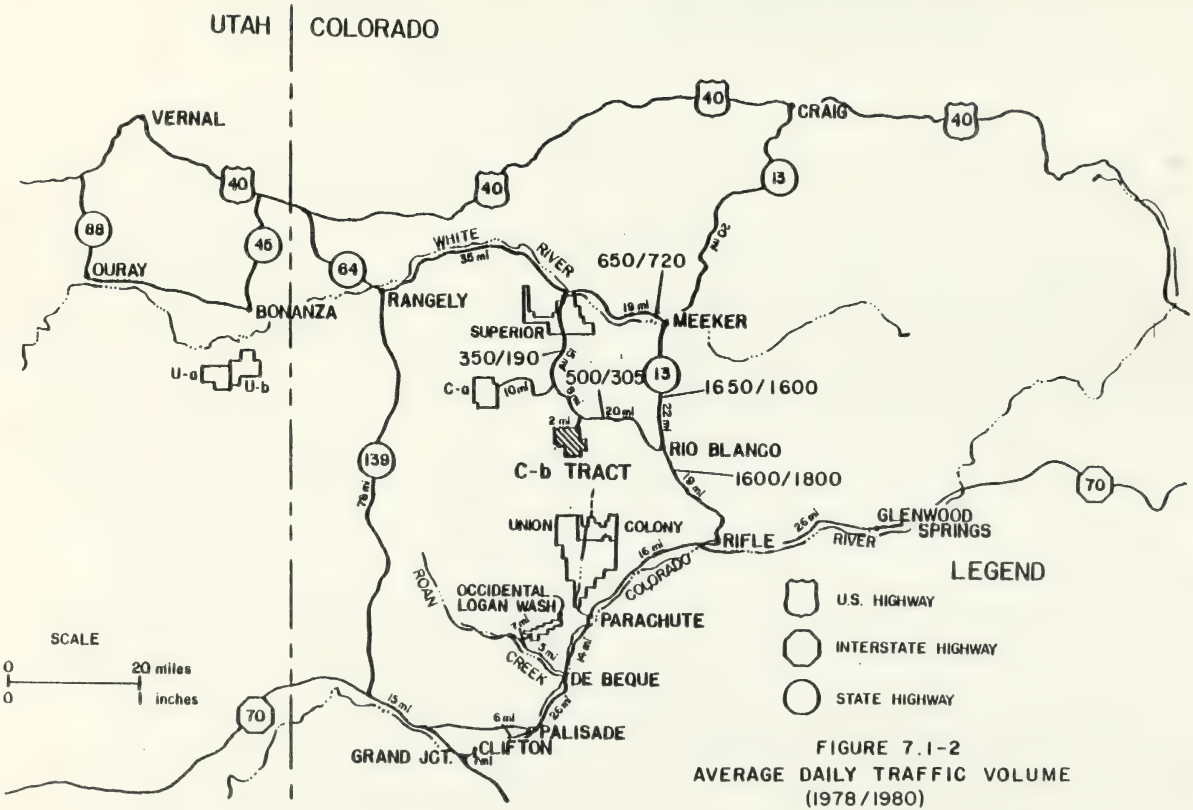


FIGURE 7.1-2
AVERAGE DAILY TRAFFIC VOLUME
(1978/1980)

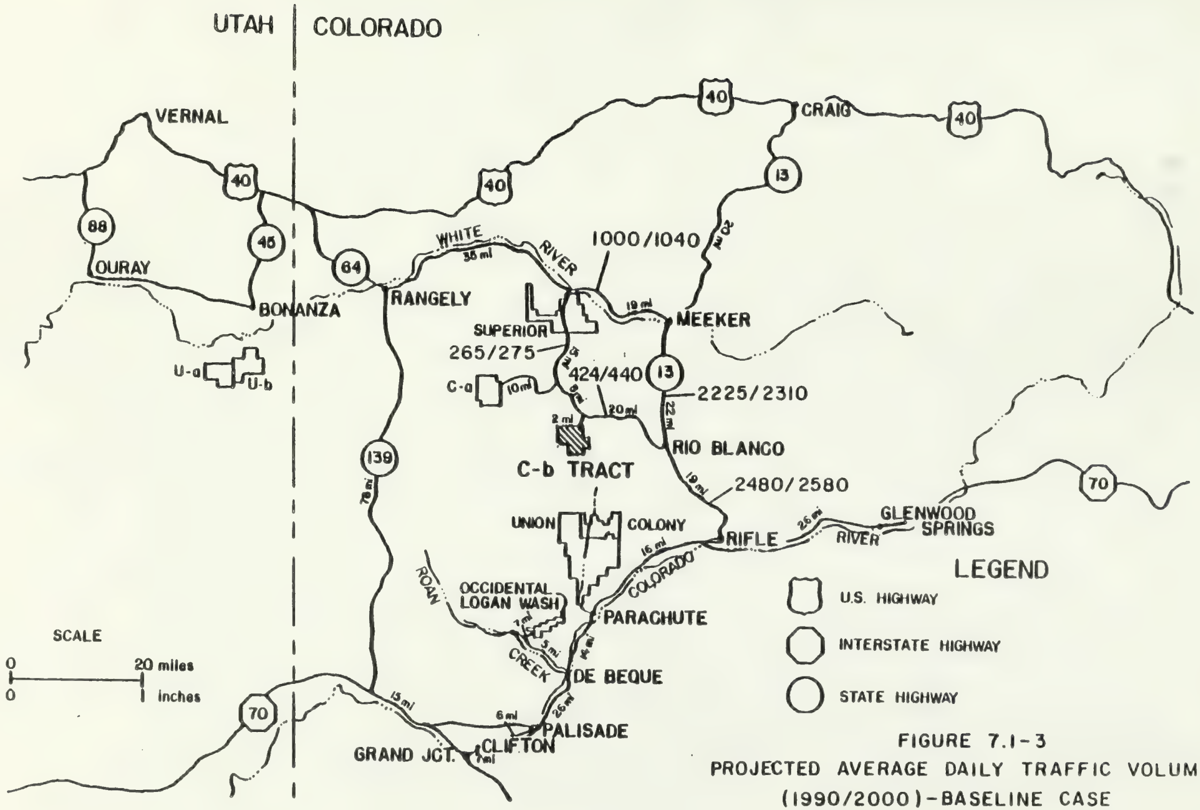


FIGURE 7.1-3
PROJECTED AVERAGE DAILY TRAFFIC VOLUME
(1990/2000)-BASELINE CASE

7.0 SOCIOECONOMICS

7.2 Regulations and Permits

TABLE OF CONTENTS

LIST OF TABLES

7.0 SOCIOECONOMICS

7.2 Regulations and Permits

Regulations concerning the socioeconomic impact of the CB Project are under the jurisdiction of local government. Rio Blanco County has a permit system in place which requires an in-depth analysis of socioeconomics. Cathedral Bluffs is currently working within the framework of the Rio Blanco County Major Development Permit to permit portions of the CB Project which were not included in the special use permit issued by Rio Blanco County in February, 1979. (These additional components were the Oil Upgrading Facility and the Onsite Housing Facility.) Table 7.2-1 contains the proposed schedule for obtaining the Major Development Permit from Rio Blanco County.

It is also contemplated that an offsite product pipeline will be constructed by CB for use in conjunction with the development of shale oil on the C-b Tract. The construction of the offsite product pipeline is not addressed in the Major Development Permit Application; rather, it is the subject of a Special Use Permit proceeding which will be handled under the appropriate Rio Blanco County Zoning Regulations. It is important to note, however, that the Construction Workforce Housing Impact Studies and related socioeconomic impact data for the offsite product pipeline are contained in the Major Development Permit Application. Such information was developed in conjunction with the studies done relating to the two additional components. As a result, the impact studies for the offsite product pipeline have already been completed in advance of an application for a Special Use Permit for the pipeline, which will occur in the future.

TABLE 7.2-1

Proposed Schedule, Rio Blanco County Major Development Permit

Submit Final Application	November, 1983
Further Review with Officials and Staff	November-January, 1984
Public Hearing(s)	January-February, 1984
Draft Permit	March, 1984
Final Permit	April, 1984

7.0 SOCIOECONOMICS

7.3 Socioeconomic Effects

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

7.0 SOCIOECONOMICS

7.3 Socioeconomic Effects

The socioeconomic effects expected to occur as a result of the CB Project are summarized below. Greater detail is available in the CB Major Development Permit Application submitted to Rio Blanco County.

7.3.1 Demographics

The development of the Project will affect Rio Blanco, Garfield and Mesa Counties, with the most significant effect upon jurisdictions in eastern Rio Blanco and western Garfield counties.

The labor force requirements of the CB Project will resemble most large industrial projects; a large number of construction workers will be required over a relatively short period of time, and a permanent operating workforce will build up during the construction period and will stabilize as full production levels are reached. Figure 7.3-1 illustrates the anticipated buildup of the construction and operations work force. A peak employment of 2900 will be reached in the first quarter of 1987. After that time, construction employment will decrease rapidly toward the targeted completion of construction in late 1988. The permanent operations work force will be 1020 employees.

During the construction stage of the Project up to 850 construction employees are expected to reside in the temporary housing facilities to be provided at the Project site. The remainder of construction employees are expected to reside in Garfield County (80%), Rio Blanco County (15%) and Mesa County (5%). Permanent Project employees are expected to reside closer to the site; 25% are projected to reside in Rio Blanco County and 75% are projected to reside in Garfield County, primarily in the communities of Meeker and Rifle.

The CB Project will have a substantial effect on total employment and total population in Rio Blanco and Garfield counties. A summary of that effect through

CATHEDRAL BLUFFS SHALE OIL PROJECT
LABOR FORCE REQUIREMENTS

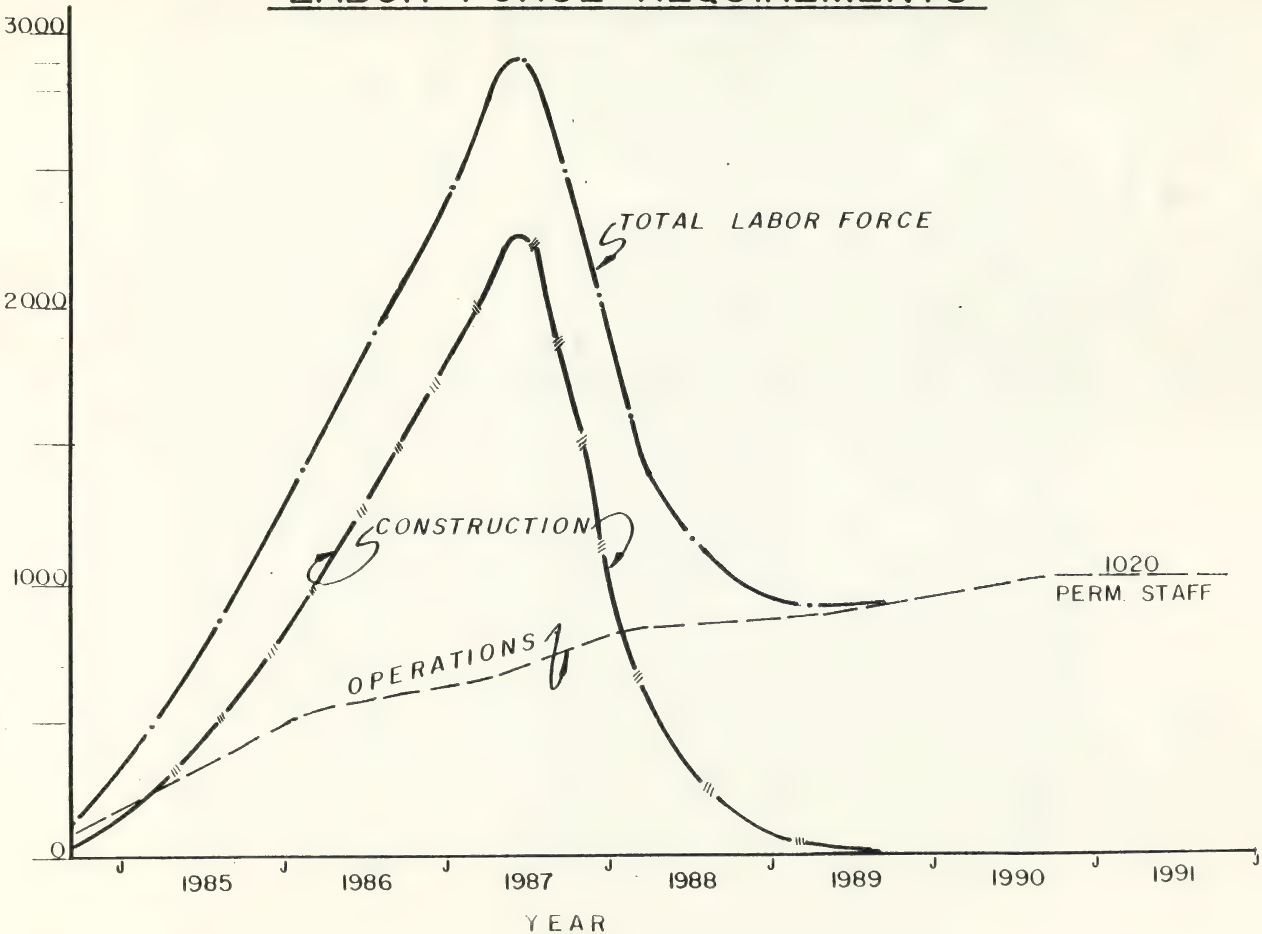


Figure 7.3-1

the construction period and up to the point of steady-state operations is displayed in Table 7.3-1. As indicated, the CB Project is projected to generate 4220 new jobs and a population increase of 5730 in the two counties during the peak of construction activity in 1987. Once steady-state operations are achieved, a total employment increase of 2410 and a population increase of 3850 in the two counties is expected to be attributable to the Project.

7.3.2 Local Economic Impacts

The CB Project is projected to increase total personal income substantially in Rio Blanco and Garfield counties. Personal income in both counties is projected to be $100 million higher in 1987 during the height of construction activity and to maintain an annual level $85 million higher than it would be without the Project, once steady-state operations begin.

The infusion of additional income into the local economy will strengthen the local business sector which is currently suffering from a period of overexpansion in 1980-1981.

7.3.3 Fiscal Balance

As indicated in Figure 7.3-2, total public sector revenues related to the CB Project are projected to exceed total public sector costs. Figure 7.3-2 is a summation of the annual revenue/expenditure balances calculated for each of the 16 local government jurisdictions in the Project area. Most jurisdictions are projected to derive long-term fiscal surpluses as a result of the CB Project. However, annual fiscal deficits are projected for many jurisdictions during the initial years of Project development due to the inability of public revenues to keep pace with operating and capital costs.

TABLE 7.3-1

Summary of Demographic Change

Year	Rio Blanco County		Garfield County		Total	
	Employment	Population	Employment	Population	Employment	Population
1985	160	220	330	260	490	480
1986	910	1290	1390	1070	2300	2360
1987	1320	2010	2900	3720	4220	5730
1988	1160	1700	2440	2990	3600	4690
1989	670	1260	2050	2750	2720	4010
1990	520	1130	1920	2770	2440	3900

FISCAL ANALYSIS SUMMARY

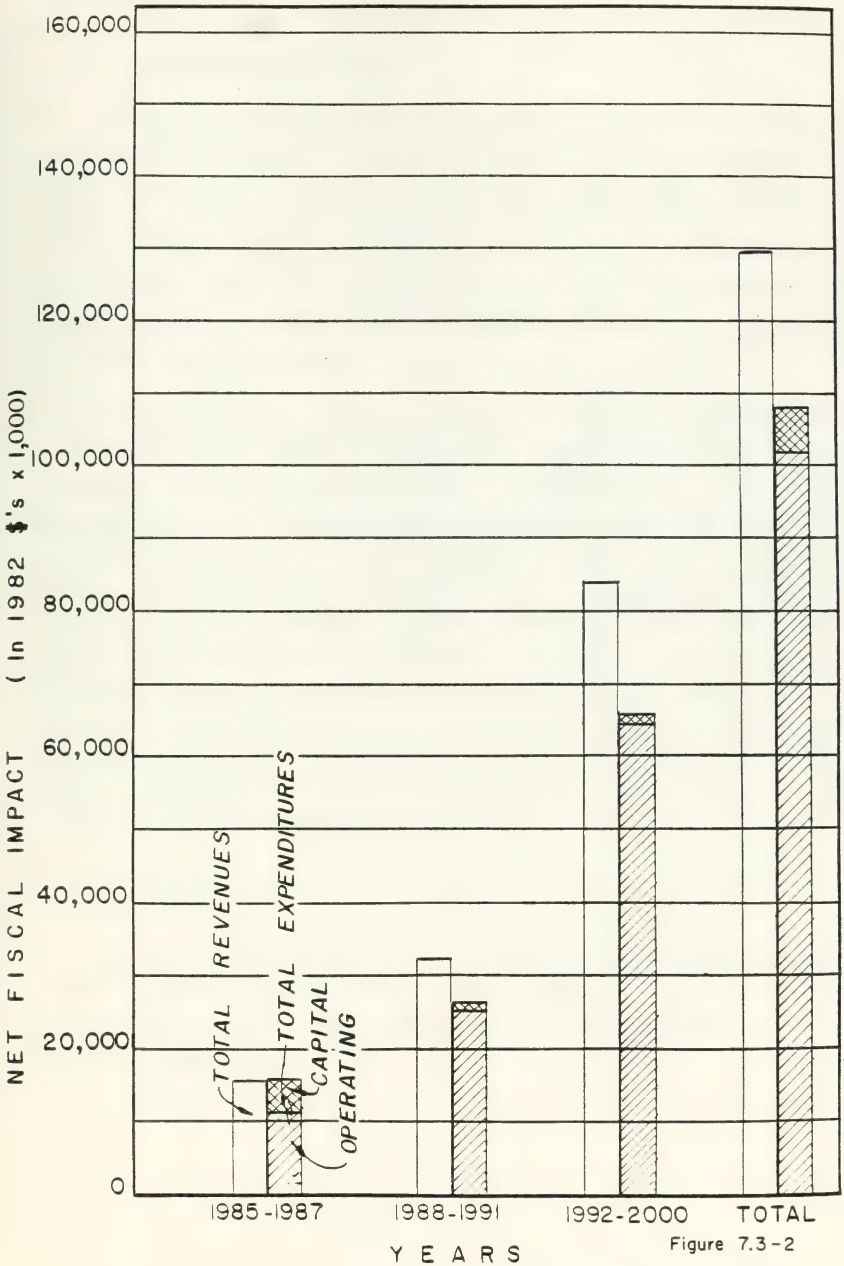


Figure 7.3-2

7.3 Socioeconomic Effects

The combination of monies remaining from the Oil Shale Trust Fund (OSTF) and the anticipated increase in property tax base is more than adequate to finance fiscal shortfalls in most jurisdictions. Five of the seven jurisdictions in Rio Blanco County expected to be impacted by the Project will receive a substantial increase in their property tax base due to the inclusion of the Project. Rio Blanco County jurisdictions also may receive financial assistance for capital expenditures from the County Capital Improvements Trust Fund, a fund derived from Oil Shale Trust Fund revenues.

Garfield County jurisdictions will receive revenues available from the Oil Shale Trust Fund to offset a portion of the expansion costs associated with the CB Project. This is particularly true in the Garfield RE-2 School District. Other Garfield County jurisdictions including the Grand River Hospital District, the Grand Valley School District, and Garfield County will receive a substantial increase in property tax base from the Union Oil Company Parachute Creek Oil Shale Project. This increased tax base, combined with some excess capacity in existing facilities, should allow these jurisdictions to offset the costs of additional growth. Those Garfield County jurisdictions without access to the Oil Shale Trust Fund or to a natural resources tax base are projected to experience the greatest difficulty in offsetting the costs of growth. These include the Town of Parachute, the Rifle Rural Fire District, and to a lesser degree, the City of Rifle and the Town of Silt.

7.3.4 Housing

The most current statistics indicate that over 1350 housing units and 636 mobile home spaces are available on a rental basis within a 75-mile driving distance from the CB Project. Table 7.3-2 provides a breakdown of total housing units and vacant units by type.

TABLE 7.3-2

Project Area Housing Stock, Mid-1983

Type of Dwelling	Number of Units/Spaces	Number of Units/ Spaces Vacant	Percent Vacant
Single-Family	4,687	224	4.8
Duplex	171	43	25.1
Multi-Family	2,373	742	31.3
Townhome/Condominium	332	93	28.0
Mobile Homes	1,130	271	24.0
Mobile Home Spaces	1,271	636	50.0
TOTAL	9,964	2,009	20.2

7.3 Socioeconomic Effects

The CB Project anticipates a need for a total of 2050 housing units for Project employees during the peak of construction activities in 1987. Up to 850 of these units will be provided as temporary housing at the Project site (see Section 7.4). Once steady-state operations begin, the total new housing required by Project employees and induced population is expected to be 1540. This housing will be available primarily from existing units supplemented by some new construction.

7.3.5 Transportation

The principal highway transportation arteries utilized by the CB Project for the transport of employees and construction materials will be Colorado Highway 13 between Rifle and Meeker, and the Piceance Creek Road from Rio Blanco to the Project site (See Figure 7.1-1). Interstate 70 both east and west of Rifle will also be utilized as the primary highway access from outside the region.

Table 7.3-3 displays the Average Daily Traffic (ADT) projected for the three key local highway segments both with and without the development of the CB Project. As indicated in Table 7.3-3, the development of the Project will not cause the design capacity of these roadways to be exceeded through the year 2000. The roadway segment that is expected to most closely approach its design capacity is Colorado Highway 13 from Rifle to Rio Blanco. Railroad facilities will be utilized to ship some Project materials to Rifle, but this will not significantly affect total railroad traffic volume.

TABLE 7.3-3

Transportation Impact Summary, 1990/2000

Roadway Segment	Roadway Design Capacity (ADT)*	Baseline Traffic Volume Projection (ADT)	CB Project Related Traffic Volume Projection (ADT)	Total Traffic Volume Projection (ADT)
Colorado Highway 13 Rifle - Rio Blanco	3215	2480/2580	280	2840/2940
Colorado Highway 13 Rio Blanco - Meeker	3215	2210/2310	50	2380/2480
Piceance Creek Road Rio Blanco - CB Site	3215	424/440	330	770/780

* Average Daily Traffic

7.0 SOCIOECONOMICS

7.4 Socioeconomic Mitigation Program

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

7.0 SOCIOECONOMICS

7.4 Socioeconomic Mitigation Program

CB is pledged to see that its employees, as well as other citizens in the oil shale area, have a good environment in which to live and work. CB is also committed to utilizing the labor resources of the local area to the greatest extent possible. This is the basis for the CB continued socioeconomic mitigation program.

CB has been active in socioeconomic impact mitigation since commencing work at the C-b Tract. Planning and financial assistance has been provided to communities and local entities. Busing and housing assistance programs have been employed as needed. Indirectly, the local share of Lease bonus payments has played a major role in financing facilities such that area communities are in a position to accommodate substantial growth. Under the cumulative outlook for growth and development, area communities can accommodate expected population growth without large additional capital investment. Should this situation change as a result of construction at Tract C-b, measures will be implemented to reduce the resultant financial burden upon local government.

7.4.1 Labor Force Recruitment and Training

CB is collecting information on labor availability, recruitment practices, and labor force training in order to respond to its future labor needs. Employment statistics, including those on oil and gas refining operations, have been analyzed to identify geographic areas with concentrations of qualified and appropriate labor. CB is also investigating methods to successfully recruit and retain a suitable labor force. Incentives and amenities are part of this analysis.

7.0 SOCIOECONOMICS

7.4 Socioeconomic Mitigation Program

7.4.1.1 Recruitment

Recruitment efforts will initially focus on Colorado and, subsequently, the western states. There is a close correlation between the skills involved in western state mining and oil shale mining and western miners are more inclined to relocate permanently than those from other regions.

An aggressive recruitment program will be implemented focusing on attracting qualified workers. Plans are being formulated with the Colorado State Labor and Training Division, local educational institutions, and Colorado Job Service offices. The Job Service offices will also assist in out-of-state recruitment efforts.

7.4.1.2 Training

Training will be provided both in-house and through educational institutions. A program of competency testing for various skills will be developed for placing applicants in training programs and for upward job movement. Unskilled applicants will be given pre-production training. In-house training will provide all skills and abilities required. Training programs will include, for example, on-the-job training, upgrading skills training, and management skills training.

Safety training will meet all Mine Safety and Health Administration (MSHA) requirements. This training will be incorporated into skills training and will address safety issues unique to the CB operation.

Implementation of the training program will require a computer-assisted manpower record system to find qualified employees as they are needed.

7.4 Socioeconomic Mitigation Program

The majority of applicant pre-screening will be conducted at the mine site. This will afford applicants the opportunity to experience the requirements of oil shale mining and will assist "screening" those individuals who have unrealistic expectations of mining.

The recruitment and training resources available to the Project and the good outlook for labor availability in the construction and mining sectors, indicate that Project labor force requirements can be met.

7.4.2 Technical Assistance

Since 1977, CB has provided specialized expertise to local government agencies to assist in the planning effort and help solve specific problems. This type of assistance has proven valuable in rural areas where local government staffs are small and unfamiliar with the problems of rapid growth. CB realizes that this type of skilled technical assistance can prevent costly mistakes and delays of public sector projects.

In 1978, CB funded the preparation of comprehensive development guides for Rifle and Meeker. These provided community leaders with detailed information on the status of all public facilities and programs. Included were projections of increased demand upon these facilities and programs, resulting from anticipated population growth. These development guides were used as a basis for planning the expansion of specific facilities and services.

Personnel with technical expertise in community organizing, public finance, city planning, recreation planning, sociology and housing were provided by CB to

assist local governments. These technicians helped to establish and also participated in both the Rio Blanco County and Garfield County impact mitigation committees. They assisted in the preparation of numerous grant requests for public project financing. They also worked with the City of Rifle to develop a sales tax proposal and a recreation district plan. In addition, they worked with Meeker citizens on a capital improvements program, a parks and recreation master plan, and they assisted Silt in developing a proposal for a subsidized housing program. They have also provided an analysis of human service needs and current programs for the use of local human service agencies. These efforts all helped to improve local socioeconomic conditions.

7.4.3 Financial Assistance

The expansion of public facilities and increased services in Garfield and Rio Blanco Counties in recent years has been paid for primarily by the Colorado Oil Shale Trust Fund (OSTF). The OSTF was established in 1974 with bonus payments made by the lessees of the oil shale prototype Tracts C-a and C-b. A total of $74 million was originally contributed to the OSTF but the accrual of interest has made it possible for the OSTF to contribute $103 million to community projects since 1975. Table 7.4-1 is a summary of public projects financed through the OSTF in western Garfield and eastern Rio Blanco counties between 1975 and 1982. Table 7.4-2 shows the amounts provided directly to northwest Colorado governments in impact assistance from the Oil Shale Trust Fund, state severance taxes and federal mineral royalties between 1975 and 1982.

The Lessees of the C-b Tract have provided additional funds for community assistance in the Project area, as detailed in Table 7.4-3. From 1978 thru 1982, CB has contributed approximately $540,000 directly to a wide variety of local groups and agencies for planning and public improvement projects. Many contributions have been made to local hospitals and service organizations in an effort to improve local health care and the human service delivery system. Along with other local oil shale projects, CB guaranteed the financing of the Rifle highway bypass route. Funding for the road improvements eventually materialized

TABLE 7.4-1

Oil Shale Trust Fund Appropriations to Western Garfield and Eastern Rio Blanco Counties - 1975 - 1982

City of Rifle	$12,631,989
Town of Silt	3,591,658
RE-2 (Rifle) School District	14,639,816
Garfield County	5,835,700
Grand River Hospital District (Rifle)	641,830
Town of Meeker	3,077,500
Meeker Sanitation District	1,808,000
RE-1 (Meeker) School District	1,982,600
Rio Blanco County	18,201,577
TOTAL	$62,410,670

Source: Colorado Department of Local Affairs

TABLE 7.4-2

Colorado's Impact Assistance Disbursements 1975-1982

County	Oil Shale Trust Fund	Energy Impact Fund	Total
Moffat	$ 5,728,391	$ 6,179,998	$ 11,908,389
Mesa	15,344,196	6,552,559	21,896,755
Garfield	42,136,158	10,005,396	52,141,534
Rio Blanco	33,852,236	2,319,510	36,171,746
Routt	966,000	4,413,384	5,379,384
Other	5,363,455*	24,960,645**	30,324,100
Total	$103,390,436	$ 54,431,492	$157,821,928

Source: Colorado Department of Local Affairs

*Funds to State Offices and Regional Council of Governments, etc.
**Funds to Other Counties

TABLE 7.4-3

Cathedral Bluffs Shale Oil Company Community Assistance Contributions 1978 - 1982

Type of Assistance		Amount
Technical Assistance		$416,202
Hospital and Health Care Contributions		21,600
Civic Organization Contributions		17,900
City/County Agency Contributions		85,000
	TOTAL	$540,702

without the need for industry funding. The bypass now minimizes heavy truck traffic in the Rifle central business district.

With the financial support of the Oil Shale Trust Fund and direct corporate contributions, local governments in the Project area are in good financial condition to accommodate the anticipated population growth. The Project will continue to work with local government officials as needed to develop financing for public projects.

7.4.4 Housing Program

To date, housing has been provided for a large portion of the Project construction work force. By providing adequate housing, the Project can attract and retain skilled and productive employees. This will minimize expenses associated with employee turnover and new-hire training.

From 1979 to mid 1982, CB owned or leased over 200 housing units. They included a 103 unit mobile home park, 42 apartments, and 10 townhouses in Rifle and 48 apartments in Meeker. The Project spent approximately $3.7 million in acquisition or lease of these properties and another $650,000 to operate and maintain them. In 1982 it was no longer necessary for CB to provide this level of employee housing; the master leases were not renewed when they expired in late 1982 and early 1983. The Project is expected to continue to own and operate the 103 unit mobile home park in Rifle and use it for employee housing once construction resumes. This property includes additional undeveloped land which can accommodate another 150 mobile home spaces.

CB also owns 113 acres of land adjacent to the mobile home park that can be developed for residential use. The property is presently being platted and annexed to the City of Rifle. Five acres of that section have been donated to Rifle as the site for a new indoor recreation center. This property

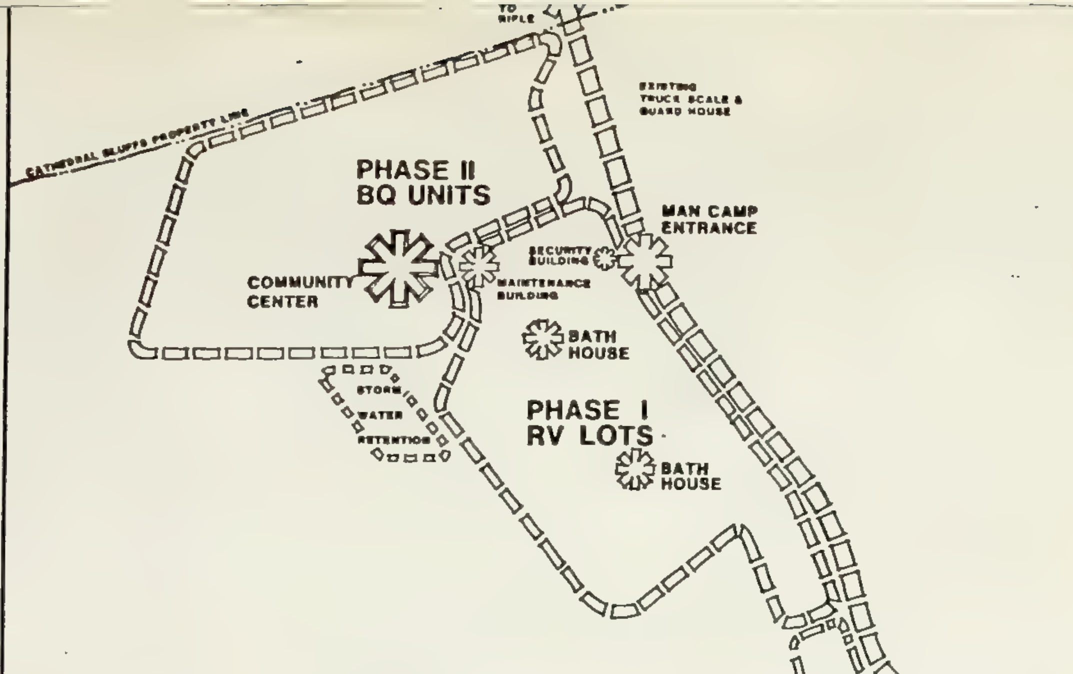
will be developed if nececessary, to provide for the projected increase in housing demand in Rifle.

The local housing market will be continually monitored to ensure that housing will be available to Project employees. At present, there is a surplus of housing in both Rifle and Meeker. In mid-1983 there were over 2000 vacant housing units within 70 driving miles of the Tract (See Table 7.3-2).

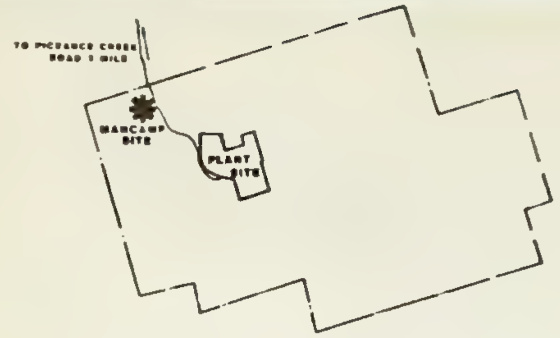
A substantial share of housing for the construction work force will be provided by a temporary housing camp on the Tract (see Figure 7.4-1). The camp will provide housing for up to 850 persons as a two-phased project. Meal service and recreation facilities will be included. See Section 3.8 for additional details on the mancamp. The housing facility will include a mix of recreational vehicle spaces and motel-style units.

Housing on-site will relieve the demand for housing upon area communities during the peak of construction activity in 1985-1988. It will also reduce the highway traffic from Rifle and Meeker to the Tract by eliminating the daily commute for many construction workers.

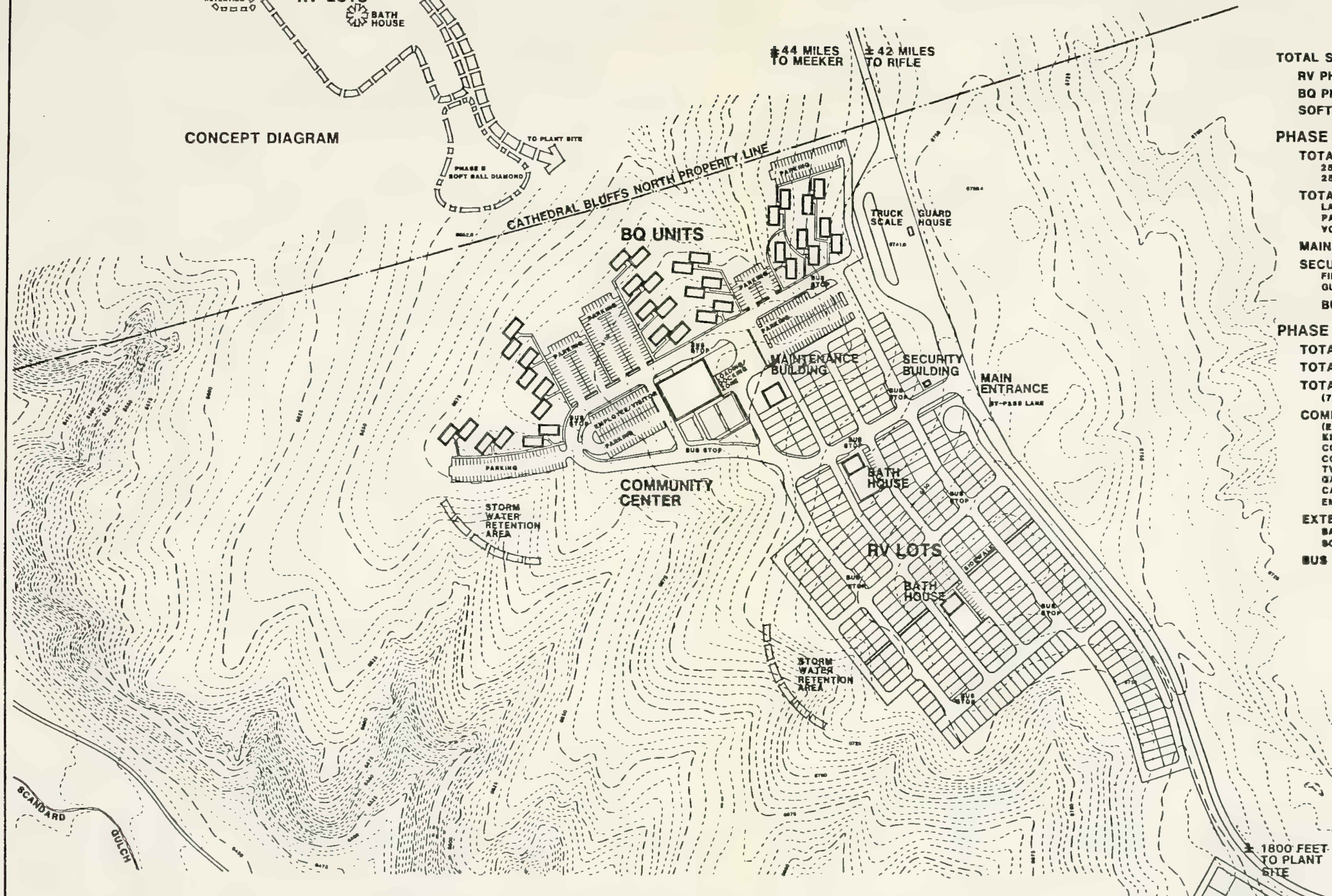
The temporary on-site housing facility should relieve the peak housing demand pressure during construction activities and permit the local housing market to accommodate the remaining growth in housing demand. CB is prepared, however, through the developable land that it now controls, to assist in the provision of housing should the current outlook change. Financial incentive programs will be offered to employees, if necessary, to facilitate the purchase of local housing and the establishment of CB employees as permanent members of the community.



CONCEPT DIAGRAM



CATHEDRAL BLUFFS PROJECT SITE



CONCEPTUAL SITE PLAN

TOTAL SITE ACREAGE	± 36.8 ACRES
RV PHASE	± 18.7 ACRES
BQ PHASE	± 16.0 ACRES
SOFTBALL	± 2.1 ACRES
PHASE I	
TOTAL RV LOTS	± 350 LOTS
25'x50'	± 290 LOTS
25'x60'	± 60 LOTS
TOTAL BATHHOUSES (EST. 2,500SF.)	2
LAUNDRY FACILITIES (EST. 840SF.)	1
PARKING (10' X 20' STALLS)	11 STALLS
VOLLEYBALL/BASKETBALL	1
MAINTENANCE BUILDING	1
SECURITY BUILDING	1
FIRST AID	
GUARD STATION	
BUS STOPS	5
PHASE II	
TOTAL BQ UNITS	500 UNITS
TOTAL BQ BLDGS. (2-STORY)	18 BLDGS.
TOTAL BQ PARKING (75% OF UNITS)(10' X 20' STALLS)	± 375 STALLS
COMMUNITY CENTER	500 MEN
(EST. 18,000SF.)	
KITCHEN/DINING	
COMMISSARY	
COMMERCIAL LAUNDRY	
TV, LOUNGE	
GAME ROOM	
CARD ROOM	
EMPLOYEE/VISITOR PARKING	± 72 STALLS
EXTERIOR RECREATION	
BASKETBALL/VOLLEYBALL	2 COURTS
SOFTBALL DIAMOND	1
BUS STOPS	5

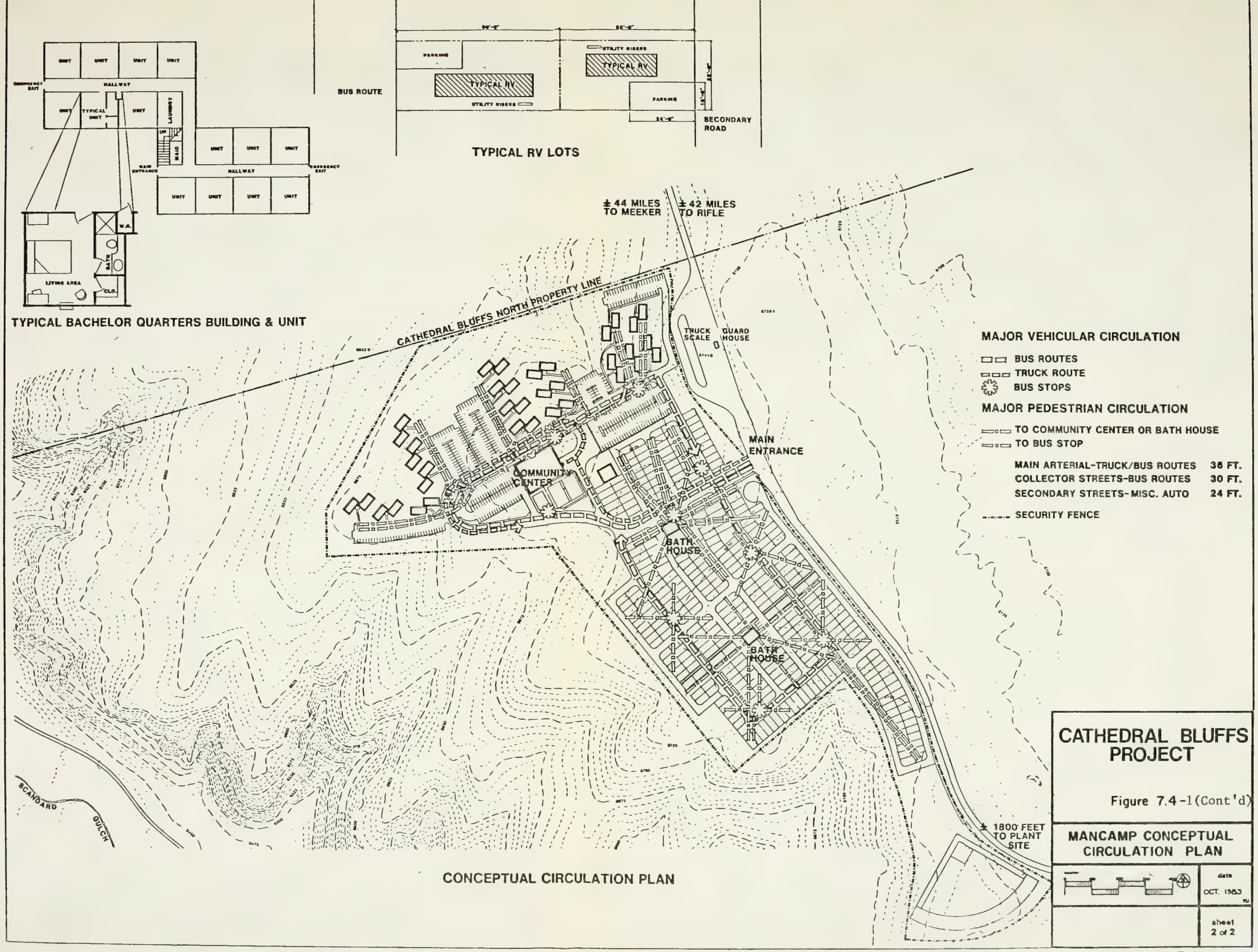
CATHEDRAL BLUFFS PROJECT

Figure 7.4-1

MANCAMP CONCEPTUAL SITE PLAN

date OCT. 1983

sheet 1 of 2


TYPICAL BACHELOR QUARTERS BUILDING & UNIT
TYPICAL RV LOTS
BUS ROUTE
PARKING
TYPICAL RV
SECONDARY ROAD
± 44 MILES TO MEEKER
± 42 MILES TO RIFLE
CATHEDRAL BLUFFS NORTH PROPERTY LINE
TRUCK SCALE
GUARD HOUSE
MAIN ENTRANCE
COMMUNITY CENTER
BATH HOUSE
BATH HOUSE
SCANDARD
GULCH
± 1800 FEET TO PLANT SITE
MAJOR VEHICULAR CIRCULATION
BUS ROUTES
TRUCK ROUTE
BUS STOPS
MAJOR PEDESTRIAN CIRCULATION
TO COMMUNITY CENTER OR BATH HOUSE
TO BUS STOP
MAIN ARTERIAL-TRUCK/BUS ROUTES 36 FT.
COLLECTOR STREETS-BUS ROUTES 30 FT.
SECONDARY STREETS-MISC. AUTO 24 FT.
SECURITY FENCE
CONCEPTUAL CIRCULATION PLAN
CATHEDRAL BLUFFS PROJECT
Figure 7.4-1(Cont'd)
MANCAMP CONCEPTUAL CIRCULATION PLAN
date OCT. 1983
sheet 2 of 2

7.4 Socioeconomic Mitigation Program

7.4.5 Transportation Program

Throughout the initial construction at C-b, bus transportation was provided from Rifle and Meeker. The bus transportation reduced highway traffic congestion and was a considerable savings to employees. The buses were also used to transport community groups from the Rifle-Meeker area to the Project site for tours and meetings with Project representatives.

The resumption of bus transportation for the employees during the construction period is planned. Buses will be used to transport employees on a daily basis from Rifle, Meeker and the Parachute/Battlement Mesa area. Buses will also be used to transport residents of the on-site housing facility to the plant site.

7.0 SOCIOECONOMICS

7.5 Contact and Coordination with State and Local Government Officials

TABLE OF CONTENTS

7.0 SOCIOECONOMICS

7.5 Contact and Coordination with State and Local Government Officials

CB has had a continuous, close working relationship with state and local government officials since the inception of the Project. Management recognizes the importance of maintaining this communication to avoid conflicts and to enable governmental agencies to plan for future growth.

Examples of this working relationship include the following:

1) In 1977, CB played a principal role in the formation of impact mitigation committees in Rio Blanco and Garfield Counties. These committees are composed of representatives of federal, state, and local government agencies, as well as representatives of local industry. The committees meet monthly to determine how plans for industrial development will specifically affect the local economic and social structure, and to analyze the ability of the public sector to respond effectively and efficiently. From these meetings, specific plans have been developed to expand necessary public facilities and services to accommodate the requirements of growth.

2) CB has contributed to the salary of the Impact Coordinator for Rio Blanco County, whose job is to identify and address socioeconomic concerns on a day-to-day basis.

3) During initial construction from 1978 to 1982, CB produced quarterly socioeconomic monitoring reports which were distributed to federal, state, and local agencies. The reports included information on work force characteristics, manpower projections, and local socioeconomic conditions. Socioeconomic monitoring and reporting will resume with initiation of site construction.

4) CB provided funding and technical assistance to the Colorado Cumulative Impacts Task Force (CITF). Senior management participates actively in CITF, working closely with city council members, county commissioners, school district superintendants, special district representatives, heads of state departments, and corporate representatives to address socioeconomic concerns.

7.5 Contact and Coordination with State and Local Government Officials

5) Project personnel maintain close contact with local service agencies and civic groups, such as the Human Resources Council, the Retired Senior Volunteer Program, Garfield County Youth Services, and the Community Resource Center.

6) CB is developing a socioeconomic impact mitigation program as part of its application to Rio Blanco County for a Major Development Permit. This program will identify and address the socioeconomic effects of CB construction upon both Rio Blanco and Garfield counties. It is planned that the program be approved by Rio Blanco County and in place before construction resumes. The program will include an extensive socioeconomic monitoring system.

CB will continue to work closely with state and local officials. This relationship should allow significant socioeconomic issues to be resolved before they become problems.

7.0 SOCIOECONOMICS

References

7.0 SOCIOECONOMICS

References

CB (1983): Major Development Permit Application. Submitted to Rio Blanco County, November, 1983.

Colorado Division of Employment and Training (1983): Colorado Labor Force Estimates, August, 1983.

Colorado Division of Employment and Training (1983): Quarterly Occupational Supply/Demand Outlook, Second Quarter, 1983.

Colorado Highway Department Design Manual, January, 1972.

Mountain West Research, Inc., (1982): CITF Technical Documentation and Summary. RE-2 School District.

Mountain West Research, Inc. (1983): Planning and Assessment System Model - An Economic and Demographic Forecasting Model. Developed by and Adapted to Western Colorado by the Colorado Cumulative Impacts Task Force. Cathedral Bluffs Estimate, October, 1983.

TABLE OF CONTENTS

Page

8.0 DEVELOPMENT MONITORING PLAN

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

TABLE OF CONTENTS

LIST OF FIGURES

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

8.1.1 Background and Scope

Section 1 (C) of the Lease Stipulations of the U. S. Department of the Interior Prototype Oil Shale Leasing Program requires the Lessee to conduct environmental baseline programs for two consecutive years and thereafter to conduct environmental monitoring programs to measure perceptible changes from the baseline conditions. This latter phase of monitoring, which is the subject of this document, is called Development Monitoring.

The Environmental Baseline Period for Oil Shale Tract C-b covered the period from November 1, 1974, to October 31, 1976. Results have been reported in 9 Quarterly Data Reports, 8 Quarterly Summary Reports, C-b Annual Summary and Trends Report (1976) and a 5-volume Environmental Baseline Program Final Report (1977), all submitted to the Oil Shale Project Office (OSPO).

From November 1, 1976 through August 31, 1977, the C-b Tract was under a period of suspension of the Federal Oil Shale Lease. The monitoring conducted during this period was executed under a program known as the Interim Monitoring Program. Environmental data for this time period were submitted to the OSPO on October 14, 1977. The Interim Monitoring period was later extended by the OSPO to cover the time from September 1, 1977, through March 31, 1978. Data for this time period were submitted to the OSPO on May 15, 1978.

The Development Monitoring Program was initiated in April 1978. The monitoring plan known as the Development Monitoring Program for Oil Shale Tract C-b was submitted to the OSPO in a document dated February 23, 1979, and approved by the OSPO on April 13, 1979, subject to 13 Conditions of Approval. (These conditions are given in the Appendix, along with a demonstration of their compliance.) Development Monitoring continued into 1982 when it again reverted to Interim Monitoring Status in March 1982 as approved by the OSPO. It has continued at that level to date. An Interim Development Program and Schedule were approved on July 22, 1982 as DDP amendments. A transition back to

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

Development Monitoring is planned during the first half of 1984 so that by July 1984 the Development Monitoring Program will be in place. Changes advocated in monitoring scope from the 1979 plan have resulted from the experience gained and data interpretations made since that time. The Development Monitoring Plan is subject to periodic revision as is now the case as part of the Revised Detailed Development Plan.

The purposes or objectives of environmental monitoring as defined in Section 1 (C) of the Lease Environmental Stipulations are to provide: 1) a record of environmental changes from conditions existing prior to development operations, as established by the collection of baseline data; 2) a continuing check on compliance with the provisions of the Lease and Environmental Stipulations, and with all applicable Federal, State and local environmental-protection and pollution control requirements; 3) a timely notice of detrimental environmental effects and conditions requiring correction; and 4) a factual basis for revision or amendment of the Stipulations.

The achievement of these objectives for Development Monitoring requires that monitoring of designated environmental parameters be conducted beginning six months prior to the commencement of development operations and until the termination of operations, or until the OSPO determines, to his satisfaction, that environmental conditions consistent with the requirements of applicable statutes and regulations have been established. The Development Monitoring Program compares data obtained during the baseline period with information developed during subsequent operations in order to identify significant and meaningful trends and changes. Trends from on-going monitoring are also assessed. It must be recognized that there may be considerable difficulty in determining the cause of an observed change from baseline conditions because of the many variables which can cause such changes. Most biological systems fluctuate around some range of mean values in response to environmental pressures. Observed departures from baseline conditions may reflect this inherent fluctuation.

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

While a two-year baseline provides gross values for measured conditions, normal yearly fluctuations may vary significantly from mean values obtained during one specific two-year period. The Development Monitoring Program for Tract C-b is designed to take these fluctuations into account and allow statistical comparisons of observed trends with baseline data and of development plots with control plots. Inherent in this is the desirability of consistency with the techniques used in the Baseline Program. Trend evaluations are performed both on a short-term basis (within one year) and over long-term.

The proposed Development Monitoring Program is flexible within guidelines provided by the Lease and is subject to periodic review and modification with the approval of the OSPO. In accordance with Lease Environmental Stipulations and conditions of the April 1979 approval of the original DMP, all monitoring results are included in semi-annual data reports and an annual analysis report to the OSPO. This program is dynamic and can be changed with approval of the OSPO to allow incorporation of new techniques and to eliminate superfluous data collection methods if such methods become identified during conduct of the Development Monitoring Program. The annual analysis report, periodic monitoring review meetings and monthly Tract coordination meetings with the OSPO provide mechanisms for achieving needed flexibility. Furthermore, the monitoring program must relate to the various phases of project development. This section of the DDP presents the Development Monitoring programs for hydrology, air quality, meteorology, noise, biology, subsidence, and health and safety together with analyses of potential ecosystem interrelationships. This plan also includes systems and statistical techniques to be used to analyze monitoring data and to interpret trends.

A relatively recent requirement has been set forth by the Synthetic Fuels Corporation (SFC) for applicants desiring SFC support. This requirement has been set forth in their Environmental Guidelines (Fed. Reg., April 1, 1983) and designated as Supplemental Monitoring, primarily for non-regulated pollutants such as organics and trace metals. Fairly extensive initial screening is

envisioned in a so-called Phase I to eliminate those pollutants of no consequence for site-specific monitoring; then in Phase II, long term monitoring is envisioned for those pollutants of significant magnitude and concern.

8.1.2 Conceptual Approach to Development Monitoring

Nine years of field experience have been incorporated into this Development Monitoring Program (DMP) including two years gained from the Environmental Baseline Program. Each of Volumes 2 through 5 (Hydrology, Air Quality, Ecology, and Ecosystem Interrelationships, respectively) of the Final Baseline Report contain a Utilization chapter which discusses planning inputs to Development Monitoring. These are incorporated into the related chapters of this document. Volume 5 is of special assistance in providing a conceptual framework for planning and is discussed below.

The approach taken in the DMP utilizes the simple, multicomponent, conceptual model shown on Figure 8.1-1. The "outputs" or actions constitute the Development Monitoring Plan and its implementation (findings) as a result of monitoring (Box 4). "Inputs" consist of the environmental data base, the Lease Environmental Stipulations, the details of Tract operations, and applicable local, state, and federal regulations (Box 1). The mid-component of "decision matrix" (Box 2) consists of the three major criteria to which candidate variables for monitoring are subjected (relatability, observability and measurability). The selected variables in the Program which are "screened" by these criteria become known as indicator variables. A significant feature of this conceptual model is its feedback capability. That is, variable levels (or magnitudes) are assessed against "expected" levels (Box 5). In the event that high levels are obtained, a "systems dependent" mode of either more intensive monitoring, use of additional stations, or added variables (or all three) is triggered as illustrated in Box 6. Feedback from the program results to date to obtain improved inputs ensures continual review and refinement of the monitoring programs as additional information is collected and analyzed. This is a

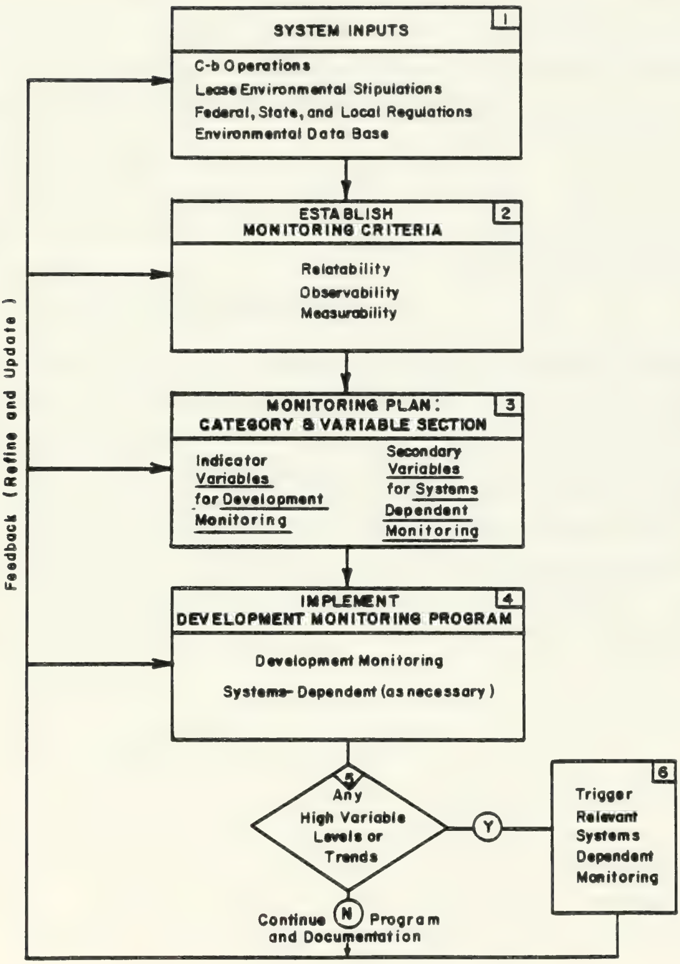


FIGURE 8.1-1 CONCEPTUAL APPROACH TO DEVELOPMENT MONITORING

provision not only for the evolution of the monitoring program in terms of methods used in collecting and analyzing data and for refining sampling frequencies and locations, but also a provision for factoring in the phases of development and their subsequent effects on the system.

8.1.2.1 System Inputs

Each of the four input category subdivisions of Box 1 is discussed in turn.

8.1.2.1.1 The Environmental Data Base

This input subdivision is composed of the data and analyses conducted as part of the two-year environmental baseline program and Tract C-b and its continuing historical additions as monitoring continues. The data contained in the environmental data base includes the areas of air quality and meteorology, surface and ground water hydrology, water quality, soils, geology, terrestrial ecology, aquatic ecology, revegetation and reclamation, archaeology, visual resources, noise, and land use. The data base, the Annual Reports and current related independent research are the main sources of information on the present condition of the Tract C-b system and for the interactions between the ecosystem components on the Tract.

8.1.2.1.2 The Environmental Lease Stipulations

This input subdivision is composed of the Environmental Stipulations appended to the Oil Shale Lease and associated Conditions of Approval for Tract C-b. They are entered into the model directly as requirements, open to revision through proper procedures if such actions are appropriately indicated by the scientific findings. These stipulations that affect monitoring are listed below:

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

1) Stipulations addressed by Baseline Studies.

   a. Collection of biotic/abiotic environmental data to determine conditions prior to development.
   b. Cultural investigations and identification of objects of historic value and scientific interest.
   c. Consideration and identification of scenic values.

2) Stipulations addressed by the Detailed Development Plan (DDP) and the Exploration Plan.

   a. Access and service plans.
   b. Fire prevention and control plans.
   c. Health and safety considerations.
   d. Spill contingency plans and disposition of hazardous materials.
   e. Control plans for air and water pollutants.
   f. Control of noise.
   g. Waste materials disposal and water impoundments.
   h. Clearing and stripping of vegetation and consideration of timber resource.
   i. Protection of historic and scientific values.
   j. Overburden management.
   k. Raw shale handling.
   l. Erosion control.
   m. Utility corridors.

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

3) Stipulations adddressed by other Documents.

   a. Fish and wildlife management and mitigation plans.
   b. Rehabilitation plans for soils and vegetation, including erosion control.
   c. Water augmentation plan.
   d. Spill contingency plan.

8.1.2.1.3 CB Operations

This input subdivision contains all the specific details of Tract development activities as depicted in the Detailed Development Plan and its modifications that influence monitoring of the physical and biological system. It is an area of concern that will be dynamic over time due to shifts in the kinds of activities as development proceeds. Major types of activities that will be reflected in the monitoring program are presented in Volume 5 of the Final Baseline Report (1977).

8.1.2.1.4 Local, State and Federal Rules and Regulations

This input category contains any rules and regulations that might pertain to Tract C-b, other than those contained in the Lease and Environmental Stipulations, or in Conditions of Approval originating from the OSPO. Examples of such rules and regulations are listed below:

1) Local Regulations

   a. Consideration of land use plans and zoning laws.
   b. Consideration of lccal, existing land uses, such as ranching and recreation.
   c. Consideration of construction requirements and permits.

2) State Laws and Regulations

a. Compliance with State of Colorado air and water pollution, and streamflow standards.
b. Compliance with State mine-land-reclamation regulations.

3) Federal Regulations

a. Compliance with federal air and water pollution standards and regulations.
b. Compliance with federal regulations governing reclamation of lands.
c. Compliance with federal occupational, and mine health and safety requirements.
d. Compliance with land use plans (BLM).
e. Compliance with SFC environmental monitoring requirements.

8.1.2.2 Selection of Monitoring Variables

The portion of the conceptual model used to select monitoring parameters consists of two parts: first, suitable criteria for selecting the indicator variables for Development Monitoring and second, the selection process itself. Indicator variables or species are those abiotic and biotic variables judged by the Lessee and the OSPO to best indicate the "state" of the system.

8.1.2.2.1 Establishing Monitoring Criteria

The three criteria of Box 2 are: 1) relatability, 2) observability, and 3) measurability.

1) Relatability to Oil Shale Development.
Variables deemed as relatable to oil shale development are those that:

a. are affected by and respond to the kinds of perturbations that result from the development of the operations scheduled for Tract C-b;
b. are those in which a change provides information relative to sensitive, important, and significant environmental features;
c. are those that are required by the Environmental Lease Stipulations and Conditions of Approval.

2) Observability in the System.

Variables that are obserable are those that:

a. are key indicators of environmental change in the Tract C-b system, and as such provide early warning of these potential changes;
b. are important components of the system that are likely to be subject to any perturbations (e.g., sensitive consumer populations such as mule deer) relating to animal growth, number and movements.

3) Measurable

Variables that meet the criterion of measurability are those that:

a. can be measured without undue expense or effort (i.e., they are "cost-effective") and that are amenable to reproducible observation by different investigators;
b. are amenable to statistical testing so that significant differences between samples can be adequately determined--or--are of the go/no-go variety;
c. are those for which the differences between project-related perturbations and naturally occurring trends can be determined;

d. are those that are comparable across diciplines, so that one given variable supplies information relative to the behavior of another variable.

8.1.2.2.2 Indicator Variables

The "candidate" variables that "pass" all the above criteria of relatability, observability, and measurability and are consistent with input constraints are required by Lease Stipulations, applicable Regulations, and permit terms are those selected as indicator variables for Development Monitoring (Box 3). The already-screened list of indicator variable is presented in Section 8.3, along with their role in impact assessment and mitigation. Subsequent chapters discuss each variable and its analysis mode.

8.1.2.3 Monitoring Categories

This section of Box 3 called "category" of the conceptual model actually consists of two parts: selection of monitoring types or categories and implementation of the Development Monitoring Program into the appropriate categories. Such implementation involves "feedback" by virtue of its dynamic nature.

8.1.2.3.1 Types of Monitoring

1) Development Monitoring

Variables placed in the development monitoring category of Box 3 are those indicator variables that meet each of the three major criteria. These variables are destined for long-term monitoring in order to maintain information regarding trends in the system. These variables will be monitored in order to establish an early indication of system change through the development of the oil shale resource on Tract C-b.

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

2) Systems Dependent Monitoring

Unexpected trends in an indicator variable may occur either over time or between control and development stations (or plots). For example, suppose the deer population on the development area declines, but the control area's deer population remains the same as baseline numbers. In this case the reduced deer population probably is not due to yearly fluctuations, but Tract activity, and may require habitat improvements to produce more forage in the control area to compensate for the development area.

Another example is that unexpectedly high readings occur at a "downwind" air quality trailer over an extended period. Such values could "trigger" the need for an additional station. Thus the number of air quality stations necessary is "system dependent," i.e., dependent on the "state of the system."

Still another example is the Phase II, Supplemental Monitoring required by the SFC wherein the exact pollutants, stations and sampling frequencies evolve from the Phase I screening process.

If professional judgments are unclear as to the cause of a fluctuation, or a series of high readings or significant trends warrant such action, a back-up study may be undertaken. This additional or back-up study, or increased number or frequency of measurements, is defined as System Dependent Monitoring. For each variable, this program will be different, but in general the variable will be more frequently sampled, on a broader scale, perhaps with additional or (new) secondary variables and/or additional sampling sites. Therefore, in addition to a development monitoring program definition, many key indicator variables may also have systems dependent monitoring additions which evolve.

8.0 DEVELOPMENT MONITORING PLAN

8.1 Introduction

8.1.2.3.2 Implementation of the Program

Development monitoring involving the selected indicator variables is accomplished as output from Box 4 of the conceptual model. Trends in these variables over time and between control and development plots are analyzed by techniques indicated on the analyses matrices described in Chapter 3. Unexpected results may "trigger" the systems dependent monitoring described above as part of "feedback" process. Quality assurance techniques as discussed in Section 8.14 will assure sampling and analysis validity. Details of the Development Monitoring Plan are discussed in the chapters to follow.

8.0 DEVELOPMENT MONITORING PLAN

8.2 <u>Tract Development Milestones and Maps</u>

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.2 Tract Development Milestones and Maps

8.2.1 Development Milestones

The following major schedules appear in this document:

Figure 3.2-1 Master Engineering, Procurement and Construction Schedule

Figure 3.3-4 Major Mining Activities Schedule

Figure 6.5-2 Surface Disruption and Reclamation Schedule

Milestones dates associated with these schedules are:

1984 Start Material Handling Facilities Development
1985 Start Surface Processing Facilities Development
1986 Offgas Shaft Operational
1986 Exhaust Shaft Operational
1987 Surface Retort Facilities Completed
1987 Aboveground Retort Startup
1987 V/E Shaft Equipped and Fully Operational
1988 Oil Upgrader Startup
1988 Ignite First MIS Retort
1989 Commencement of Commercial Production
1989 AGR Steady State Production
1989 MIS Retort Steady State Production
1989 Oil Upgrader Steady State Production

8.0 DEVELOPMENT MONITORING PLAN

8.2 Tract Development Milestones and Maps

Full production of 14,100 barrels per calendar day (BPCD) of syncrude from the oil upgrader is scheduled to occur in 1989, as obtained from processing 13,260 BPCD of raw shale oil; of this, a total MIS production rate of 2,260 BPCD of raw shale oil and full AGR production rate of 11,000 BPCD of raw shale oil is achieved.

8.2.2 Maps

8.2.2.1 Topographic Mapping

In September 1980, the entire Tract was overflown and photographed for aerial mapping. Photographs were taken from two elevations to provide maps of the entire Tract on a 5-foot contour interval, 1:24000 scale. Mapping at 1:2400 scale was completed in early February 1981. This task resulted in the following maps:

Drawing No.	
AD-0030	Area 12 Topo Map
AD-0029	Area 11 Topo Map
AD-0028	Area 10 Topo Map
AD-0027	Area 9 Topo Map
AD-0026	Area 8 Topo Map
AD-0025	Area 7 Topo Map
AD-0024	Area 6 Topo Map
AD-0023	Area 5 Topo Map
AD-0022	Area 4 Topo Map
AD-0021	Area 3 Topo Map
AD-0020	Area 2 Topo Map
AD-0019	Area 1 Topo Map
AD-0017	1:7200 Topo Map
AD-0016	1:7200 Topo Map

8.0 DEVELOPMENT MONITORING PLAN

8.2 Tract Development Milestones and Maps

The index in this set is drawing AD-0018. The complete set to reduced size has been provided to the OSPO.

8.2.2.2 Plot Plan

A general plot plan of the facilities has been prepared:

Dwg No.	Title	Scale	Reproduced as 11" x 17" in the DDP as Figure
3500-A-01M	Plot Plan Overall C-b Tract	1:600	3.2-2
3500-A-02M	Plot Plan CB Plant	1:200	3.2-3
AD-0501-M	Plot Plan Surface Mine Support Area	1:100	3.2-4

An on-Tract facilities list appears on Figure 3.2-3.

8.2.2.3 Shale Pile Development

Maps depicting shale-pile development are shown in this document for the following years:

Figure 3.4-2 Year 12
Figure 3.4-3 Ultimate Configuration

Dark areas are the exposed or working faces of the raw and processed shale piles.

8.2 Tract Development Milestones and Maps

8.2.2.4 Monitoring Plan

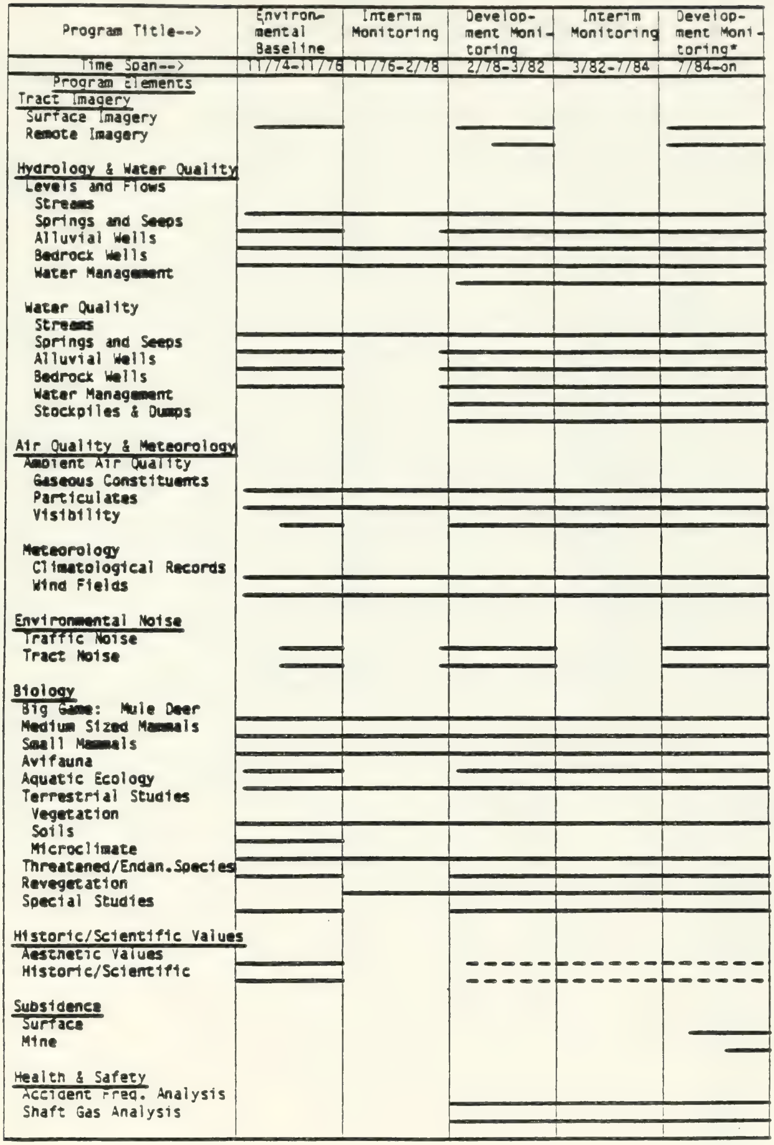
An overview of the monitoring programs conducted since baseline is shown on Figure 8.2-1. Relevant maps depicting station locations and associated computer codes are as follows:

Time Span	Monitoring Program	Where Provided
11/74-11/76	Environmental Baseline	Environmental Program Final Baseline Report
11/76-2/78	Interim Monitoring	CB Data Reports to the OSPO (10/14/77 and 3/31/78)
2/78-3/82	Development Monitoring	CB Data Reports
After 8/79	Additions due to Water Augmentation Plan	Exhibit A, Figure 6.3-1, this document Exhibit B, Table 6.3-2, this document
3/82-7/84	Interim Monitoring	CB Data Reports
After 7/84	Development Monitoring	Available in mid-1984

The 4-digit computer codes and stations identifications are listed in Table 8.2-1.

Figure 8.2-1

CB Environmental Monitoring Program Overview



* Approximation only - Details are yet to be worked out with Oil Shale Projects Office.

TABLE 8.2-1
Computer Code and Station I.D. Cross-Reference

I Air Quality & Meteorology

	Station Designation	Computer Code
Met. Tower:	@ Sta. 023	AA23
Trailers:	020	AB20
	021	AB21
	022	AB22
	023	AB23
	024	AB24
Monostatic Acoustic Radar	Sta. 020	AC20
	021	AC21
	023	AC23
Weather Station and Particulates	Sta. 020	AD20
	031	AD31
	032	AD32
	033	AD33
	041	AD41
	042	AD42
	043	AD43
	044	AD44
	056	AD56
Visibility	View I	AV01
	View II	AV02
	View III	AV03
	View IV	AV04

II Biology

Deer Pellet Group Densities

Vegetation Type	Location	Treatment	Transect (Computer Code)
CPJ	Off Tract	Control	BA01
			BA02
			BA03
			BA04
			BA05
			BA06
			BA07
			BA08
			BA09
	On Tract		BA17
			BA18
			BA25
			BA28
			BA29
			BA30
			BA31

TABLE 8.2-1 (Contd)

Biology (Contd)

Vegetation Type	Location	Treatment	Transect (Computer Code)
CPJ	On Tract	Development	BA32
		Sprinkler	BA20
		Development	BA21
			BA23
PJ	Off Tract	Control	BA13
			BA14
			BA15
		Development	BA10
			BA11
			BA12
			BA16
	On Tract	Control	BA19
			BA26
			BA27
		Development	BA22
			BA24
Brush Beaten*	Off Tract	Development	BA41
			BA42
			BA43
			BA44
			BA45
			BA46
			BA47
			BA48
			BA49

* Fenced Sagebrush

TABLE 8.2-1 (Contd)

Biology (Contd)

Programs: Deer Distribution & Migration and Road Kills

Mile Marker	Location	Computer Code: North & East of Piceance Creek Road	Computer Code: Meadows; South & West of Piceance Creek Road
41	White River City	BN41	BM41
40	Piceance Bridge	BN40	BM40
39	Lower Canyon	BN39	BM39
38	Piceance Canyon	BN38	BM38
37	Yellow Creek	BN37	BM37
36	Stinking Springs	BN36	BM36
35	Old Bridge	BN35	BM35
34	Little Hills Turnoff	BN34	BM34
33	Old Corrals & Buildings	BN33	BM33
32	Burk Ranch	BN32	BM32
31	Ranch	BN31	BM31
30		BN30	BM30
29		BN29	BM29
28	Bureau of Mines	BN28	BM28
27	Ryan Gulch	BN27	BM27
26	Pump Station	BN26	BM26
25		BN25	BM25
24	Rock School	BN24	BM24
23	AQ Trailer 021 Baseline Location	BN23	BM23
22	Pat Johnson's Ranch	BN22	BM22
21	Hunter Creek	BN21	BM21
20	PL Gate	BN20	BM20
19	AQ Trailer 020 Baseline Location	BN19	BM19
18	Sorghum, Cottonwood	BN18	BM18
17	Stewart Gulch Rd.	BN17	BM17
16	AQ Trailer 022 Baseline Location	BN16	BM16
15	Oldland's Ranch	BN15	BM15
14	Oldland's Ranch	BN14	BM14
13	Pond and Cabin	BN13	BM13
12	Sprague Gulch	BN12	BM12
11	Cascade Gulch	BN11	BM11
10	13 Mile Gulch	BN10	BM10
9	14 Mile Gulch	BN09	BM09
8	Schutte Gulch	BN08	BM08
7	Robinson's Ranch	BN07	BM07
6		BN06	BM06
5	2 Old Cabins (35 MPH Curve)	BN05	BM05
4	McCarthy Gulch	BN04	BM04
3	Cow Creek	BN03	BM03
2	Mahogany Outcropping	BN02	BM02
1	Woodward Ranch	BN01	BM01
0	Rio Blanco Store	BN00	BM00

TABLE 8.2-1 (Contd)

Biology (Contd)

Programs	General Location	Computer Code
Deer Mortality	North Side of Piceance Creek	BD01
		BD02
		BD03
		BD04
		BD05
		BD06
	South Side of Piceance Creek	BD07
		BD08
		BD09
		BD10
Deer Age Class	General Area of Tract	BF01
Coyote Abundance	8 Transects for Total for 30 miles	BF01
	15 mi seg. near Hunter (Control)	BF02 thru BF08
	15 mi seg. on & South of Tract (Development)	
Lagomorph Abundance	Identical Locations to Those for Deer Pellet Group Density Measurements	BA01 to BA49
Small Mammals	Piceance Creek (Development)	BG01
	On-Tract-West	BG02
	Piceance Creek (Control)	BG03
	On-Tract-East	BG04
	Sprinkler Area Section B	BG05
	Sprinkler Area (Control)	BG11
	Sprinkler Area (Development	BG22
	Sprinkler Area (Control)	BG33
Avifauna		
Songbirds and Gamebirds	N.W. of Tract-near Jimmy PJ-CH-C	BH01
	On-Tract-Scandard PJ- -D	BH02
	On-Tract-Cottonwood PJ-CH-D	BH03
	S. of Tract-Between W&N Fork Stewart PJ-CH-C	BH04
	Sprinkler	BH05
Raptors	The Entire Tract and Surrounding Study Areas	BI01
Aquatic Ecology		
Benthos	USGS 09306007 (Control)	WU07
	USGS 09306058 (Development)	WU58
	USGS 09306061 (Development)	WU61
Periphyton	Piceance Creek Upstream (Control)	WP01
		WP02
	Piceance Creek Downstream (Development)	WP03

Biology (Contd)

Programs	General Location	Computer Code		
Water Quality	USGS 09306061 (Development)	WU61		
Vegetation				
Community Structure	Plots	*	**	***
	Chained pinyon juniper (1978)(Dev)	BJ01	BJ11	BJ21
	Chained pinyon juniper (1978)(Cont)	BJ02	BJ12	BJ22
	Upland sagebrush (1980)(Cont)	BJ03	BJ13	BJ23
	Bottomland sagebrush (1980)(Cont)	BJ04	BJ14	BJ24
	Pinyon juniper woodland (1979)(Dev)	BJ05	BJ15	BJ25
	Pinyon juniper woodland (1979)(Cont)	BJ06	BJ16	BJ26
Micro Climate	MC Sta. 1	BC01		
	2	BC02		
	3	BC03		
	4	BC04		
	5	BC05		
	6	BC06		
	7	BC07		
	8	BC08		
	9	BC09		
	13	BC13		
Traffic Count	Rio Blanco Store	BT01		
	South of Cattle Guard	BT02		
	Rio Blanco Lake	BT03		

III Noise

Programs	General Location	Computer Code
Traffic Noise	Sta. IX	NB01
	XV	NB15

TABLE 8.2-1 (Contd)

Biology (Contd)

Program	General Location	Computer Code
Photography		
	P1	PA01
	P2	PA02
	P3	PA03
	P4	PA04
	P5	PA05
	P6	PA06
	P7	PA07
	P8	PA08
	P9	PA09
	P10	PA10
	P11	PA11
	P12	PA12
	P13	PA13
	P14	PA14
	P15	PA15
	P16	PA16
	P17	PA17
	P18	PA18
	P19	PA19
	P20	PA20
	P21	PA21
	P22	PA22
	P23	PA23
	P24	PA24
	P25	PA25
	P26	PA26
	P27	PA27
	P28	PA28
	P29	PA29
	P30	PA30
	P31	PA31
	P32	PA32
	P33	PA33
	P34	PA34
	P35	PA35

TABLE 8.2-1 (Contd)

. Water

Program	Station Designation	Computer Code	Elevation(ft)
USGS Stream Gauging Station	09304800	WU48	
	09306007	WU07	
	09306036	WU36	
	09306039	WU39	
	09306042	WU42	
	09306061	WU61	
	09306050	WU50	
	09306052	WU52	
	09306058	WU58	
	09306033	WU33	
	09306025	WU25	
	09306015	WU15	
	09306028	WU28	
	09306022	WU22	
	09306200	WU00	
	09306222	WU62	
	09306255	WU55	
Alluvial Wells	A-1	WA01	6282.2
	A-2	WA02	6284.5
	A-3	WA03	6448.6
	A-4	WA04	0000.0
	A-5	WA05	6345.0
	A-5A	WA55	6460.0
	A-5B	WA56	6460.0
	A-6	WA06	6360.0
	A-7	WA07	6383.8
	A-8	WA08	6409.0
	A-9	WA09	6540.2
	A-10	WA10	6610.6
	A-11	WA11	6503.8
	A-12	WA12	6691.8
	A-13	WA13	0000.0
	A-102-1	WA21	6292.0
	A-102-2	WA22	6290.0
Springs and Seeps	CB S-1	WS01	
	CB S-2	WS02	
	CB S-3	WS03	
	CB S-4	WS04	
	CB S-6	WS06	
	CB S-6A	WS66	
	CB S-7	WS07	
	CB S-8	WS08	
	CB S-9	WS09	
	CB S-10 (W-3)	WS10 (WS34)	
	CB Seep A	WS11	
	CB S-102	WS12	
	CB S-102A	WS13	6300.01

TABLE 8.2-1 (Contd)

V. Water (Contd)

Program	Station Designation	Computer Code	Elevation(ft)
Springs and Seeps (Contd)	CER-1	WS21	
	B-3	WS22	
	H-3	WS23	
	F-3	WS24	
	Figure 4-A	WS25	
	W-4	WS26	
	W-9	WS27	
	CER-7	WS28	
	S-9	WS29	
	P3 & P3A	WS30	
	CER-6	WS31	
	W-2 (S-9)	WS32 (WS09)	
	S-2	WW33	
	W-3 (CB S-10)	WS34 (WS10)	
	Figure 4	WS35	
	CB S-11 (S-101)	WS36	
	Oldland Spring	WS37	
Precipitation	CB-020	AB20	
	CB-023	AB23	
	Raw Shale Leachate Pile	AD28	
	LH	WR01	
	M	WR02	
	SG	WR03	
	CG	WR04	
	JQS	WR05	
	EFPC	WR06	
	EMFPC	WR07	
	UCBW	WR08	

TABLE 8.2-1 (Contd)

V. Water (contd)
Upper Aquifer Wells

Before Recompletions			Recompletion #1			Recompletion #2		
Station	Code	Elevation(ft)	Station	Code	Date	Station	Code	Date
CB-2	WX02	6737.0	CB-2	WD02	11-18-80			
CB-4	WX04	7057.3	CB-4	WE04	11-20-80			
SG-10A	WX10	6953.6	SG-10A-1	WE10	*	SG-10A-1	WG51	
			SG-10A-2	WD10	*	SG-10A-2	WE51	*
						SG-10A-Annulus	WD51	
SG-1A	WX11	6425.0	SG-1A-1	WE11	12-12-80			
			SG-1A-2	WD11	12-12-80			
SG-1-2	WX12	6428.6	SG-1 -2	WD12	11-01-80			
14X-7	WX14	6909.0	14X-7-1	WD14	11-15-80			
			14X-7-2	WD15	11-15-80			
SG-17-2	WX17	7038.6				SG-17-2	WE17	11-03-80
						SG-17-3	WD17	11-03-80
						SG-17-4	WC17	11-03-80
SG-18A	WX18	7386.6	SG-18A-1	WG18	12-02-80			
			SG-18A-2	WE18	12-01-80			
			SG-18A-3	WD18	12-02-80			
SG-19	WX19	6384.4	SG-19	WD19				
SG-20	WX20	6358.0	SG-20-1	WG20	11-15-80			
			SG-20-2	WE20	11-15-80			
			SG-20-3	WD20	11-15-80			
SG-21	WX21	6813.3	SG-21-1	WH21	12-08-80			
			SG-21-2	WG21	12-08-80			
			SG-21-3	WE21	12-08-80			
			SG-21-4	WD21	12-09-80			
AT-1C-3	WX44	6906.0						
SG-11-3	WX55	6903.1				SG-11-3	WD52	10-18-80
SG-6-3	WX63	6890.7	SG-6-3	WD61	10-20-80			
SG-8-2	WX82	0000.0						
SG-9-2	WX92	6873.0	SG-9-2	WE91	12-11-80			
			SG-9-3	WD91	12-11-80			
			SG-9-4	WC91	12-12-80			
32X-12	WX32	6830.3						
33X-1	WX33	6707.1						
41X-1	WX41	6460.0						
TH75-5A	WX64	7178.0						
TH75-13A	WX65	6390.0						
TH75-18A	WX67	6740.0						
TH75-9A	WX69	7350.0						
CER RB-D-02	WX71	6580.0						
TH75-15A	WX72	6805.0						
UNION 8-1	WX73	8142.3						
COLONY 12-596	WX74	0000.0						
TH-5	WX75	7583.2						

* Recompletion #1 not satisfactory for these strings: use #2.

TABLE 8.2-1 (Contd)

/. Water (contd)

Lower Aquifer Wells

Before Recompletions			Recompletion #1			Recompletion #2		
Station	Code	Elevation'	Station	Code	Date	Station	Code	Date
CB-1	WY01	6763.4	CB-1	WD01	11-14-80			
CB-3	WY03	6743.1	CB-3	WE03	11-18-80			
SG-10	WY09	6952.5	SG-10R	WG10		SG-10	WD90	
SG-1-1	WY12	6428.8	SG-1-1	WG12	11-1-80			
SG-17-1	WY18	7038.6	SG-17-1R	WY17		SG-17-1	WG17	11-03-80
AT-1C-1	WY45	6906.0						
AT-1C-2	WY46	6906.0						
SG-11-1	WY51	6903.1	SG-11-1R	WY52		SG-11-1	WG52	10-18-80
SG-11-2	WY54	6903.1				SG-11-2	WE52	10-18-80
SG-6-1	WY61	6890.7	SG-6-1	WE61	10-20-80			
SG-6-2	WY62	6890.7	SG-6-2	WG61	10-20-80			
SG-8	WY80	6540.8	SG-8R	WY81				
SG-9-1	WY91	6873.0	SG-9-1	WG91	12-11-80			
AT-1	WY44	6909.0						
TH75-5B	WY64	7178.0						
TH75-13B	WY65	6390.0						
EQUITY-1	WY66	6286.0						
TH75-10B	WY68	6840.0						
TH75-9B	WY69	7350.0						
EQUITY-S-1A	WY70	7070.0						
CER RB-D-03	WY71	6580.0						
TH75-15B	WY72	6805.0						
TG71-3	WY75	6820.0						
TG71-5	WY76	6865.0						
GETTY 9-40	WY77	7777.8						
TG71-4	WY78	7145.0						
EQUITY BS-13	WY79	7020.0						

New Wells

Station	Code	Date	Elevation (ft)
SG-17A	WD57	12-02-80	7036.0
AT-1D-1	WG41	11-16-80	6909.0
AT-1D-2	WE41	11-16-80	6909.0
AT-1D-3	WD41	11-16-80	6909.0
AT-1A	WV37		6909.0
AT-1A1	WX38		6909.0
AT-1B	WV40		6909.0

V. Water (contd)

	Before Recompletions			Recompletion #1		
	Station	Code	Elevation'	Station	Code	Date
Composite Wells:						
	GREENO 404	WV01	6411.0			
	OLDLAND 3	WV02	6490.0			
	GP-17X-BG	WV03				
	BUTE 25	WV04				
	LIBERTY BELL 12	WV05	7420.0			
	TOSCO WELL	WV06				
	21X12	WV07	6794.8	21X12-1	WG23	5/83
				21X12-2	WC23	5/83
	22X1	WV08	6704.1	22X1-1	WE22	5/83
				22X1-2	WD22	5/83
				22X1-3	WC22	5/83
	43X2	WV09	6692.7	43X2-1	WG43	5/83
				43X2-2	WE43	5/83
	(TG71-1)71X1	WV10	6660.0			
Seepage Monitoring Wells:						
	32Y-12	WW32	6785.0			
	31X-12	WW12	6764.0	31X12	WW22	11/80
	41X-13-2	WW13	6953.6			
Reinjection Wells:						
	22X-17	WI19				
	11X-18	WI18	6950.0			
	24X-17	WI17				
Leau' Claire Filter:						
	BEFORE FILTER	WQ01				
	AFTER FILTER	WQ02				
	AT REINJECTION POINT	WQ03				
Ponds:						
	POND A	WN01	6770.2			
	POND B	WN02	6770.2			
	POND C	WN03	6950.0			
	POND A SPRINGS	WN11				
	POND B SPRINGS	WN12				
	POND C SPRINGS	WN13				
	POND A INLET	WN21				
	POND B INLET	WN22				
	POND C INLET	WN23				
	POND A-B CROSSOVER	WN31				
	POND B OUTLET	WN32				
	POND C OUTLET	WN33				
	BACKWASH POND	WN04				
	BACKWASH POND SPRINGS	WN14				
	BACKWASH POND INLET	WN24				
	BACKWASH POND OUTLET	WN34				
	POND A-B DISCHARGE	WN40				
Shafts:						
	V/E SHAFT PROBE HOLES	WZ01				
	SERVICE SHAFT PROBE HOLES	WZ02				
	PRODUCTION SHAFT PROBE HOLES	WZ03				
	V/E SHAFT WATER RING	WZ11				
	SERVICE SHAFT WATER RING	WZ12				
	PRODUCTION SHAFT WATER RING	WZ13				

TABLE 8.2-1 (Contd)

V. Water (contd)

	Before Recompletions			Recompletion #1		
	Station	Code	Elevation'	Station	Code	Date
	V/E SHAFT SUMP	WZ21				
	SERVICE SHAFT SUMP	WZ22				
	PRODUCTION SHAFT SUMP	WZ23				
	V/E SHAFT	WZ31				
	PRODUCTION SHAFT	WZ33				
	SHAFT GROUT HOLE	WZ41				
Discharge Monitoring Stations						
	NO NAME GULCH	WU42				
	UPPER PICEANCE CREEK	WN41				
	LOWER PICEANCE CREEK	WN42				
	HUNTER CREEK	WU02				
	WILLOW CREEK	WU01				
Mobil Wells	WELL NO. 1	MW01	6510			
	WELL NO. 2	MW03	6480			
	WELL NO. 3	MW03	6618			
	WELL NO. 12	MW12	6486			
	WELL NO. 13	MW13	6509			

8.0 DEVELOPMENT MONITORING PLAN

8.3 Indicator Variables

TABLE OF CONTENTS

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.3 Indicator Variables

8.3.1 Introduction, Scope, and Rationale

Examination of the number of sampling stations multiplied by the number of variables sampled multiplied by number of samples taken in a year's time clearly identifies that a tremendous amount of data is being collected. Indeed the central problem of this entire section is to provide the means to detect trends in the least number of variables that can provide a manageable, true perspective of environmental change.

This Section attempts to initiate the solution of this problem by the use of indicator variables. Indicator variables are those monitored, environmental parameters that can be expected to provide the earliest clues of potential change from the baseline environment. This chapter identifies the indicator variables selected for environmental disciplines of hydrology and water quality, air quality and meteorology, noise, and biology. Site locations are discussed in sections dealing with the respective disciplines.

In the case of unregulated pollutants for air and water, indicator variables will evolve from Phase I (broad-based) screening techniques, from which those variables of signifance will be obtained for long-term monitoring in a second phase, called Phase II.

8.3.2 Nomenclature

Action Level	Magnitude of an indicator variable or its trend which triggers systems dependent monitoring.
Class I Indicator Variables	Those sampled at least monthly.
Class II Indicator Variables	Those sampled less frequently than monthly.

8.3 Indicator Variables

Indicator Variable	Those measured environmental variables selected for monitoring because they are expected to provide earliest clues of potential change from the baseline environment.
Linear Trend	Linear variation over time or linear fit to the trend.
Measured	Sampled via field measurement.
Reporting Interval	Most frequent tabulation interval (over time) in the data base.
Trend	Variation over time.
Variable	A quantity capable of assuming any of a set of values.

8.3.3 Role in Effects Assessment

These variables are: (1) most sensitive to change in quality; (2) indicators of natural or climatic change; and (3) subject to federal and state standards because of concern for human health and public welfare.

Via early data reduction and analysis, changes or adverse time-trends in the observations can be flagged in timely fashion. Visibility is provided by maintaining current time-series plots of the key variables, as appropriate. Impact of development activity is also assessed through statistical comparison of data collected on both development (impacted) and control (non-impacted) sites. If trends and differences signal adverse environmental impact, additional and increased monitoring will be triggered (referred to as Systems Dependent Monitoring in Section 8.1); and, if necessary, control measures could be implemented.

8.3.4 Identification of Class I Indicator Variables

Indicator variables are that subset of the environmental parameters that best indicate the "state" of the ecosystem. However, the combinations of monitored indicator variables and collection stations exceed 1000. Therefore, Class I Indicator Variables have been identified in order to further reduce the number of parameter and site combinations to a realistic quantity for the purpose of close observation and more detailed analysis. Class I Indicator Variables are key environmental variables collected at representative stations on at least monthly frequency. This frequency-distinction is entirely arbitrary; this frequency makes them amenable to time series plotting.

This chapter identifies only the Class I Indicator Variables; however, all monitored variables are included in the data reports.

8.3.4.1 Tract Imagery

Tract imagery is carried out under both a surface and an aerial program. The recent aerial program has consisted of historical and present use of Landsat digital data. Black and white aerial photography is planned every three years. No Class I Indicator Variables associated with tract imagery are identified at present.

8.3.4.2 Hydrology and Water Quality

Class I Indicator Variables for hydrology are identified in Table 8.3-1. Parameters are collected either daily or monthly as indicated by the codes in the table.

8.3.4.3 Air Quality and Meteorology

Class I Indicator Variables and Stations for air quality and meteorology are

TABLE 8.3-1

Hydrology and Water Quality Class I Indicator Variables

	Surface Streams					Springs and Seeps					Alluvial Wells				Deep Wells
	WU07	WU42	WU61	WU58	WU22	WS01	WS03	WS06	WS07	WS12	WA03	WA05	WA06	WA08	
Ammonia	M	M	M	M	M										
Boron	M	M	M	M	M										
Fluoride	M	M	M	M	M										
Total Dissolved Solids	M	M	M	M	M										
Arsenic	M	M	M	M	M										
Total Suspended Solids	M	M	M	M	M										
Aluminum	M	M	M	M	M										
Cadmium	M	M	M	M	M										
Copper	M	M	M	M	M										
Iron	M	M	M	M	M										
Silver	M	M	M	M	M										
Zinc	M	M	M	M	M										
Mercury	M	M	M	M	M										
Phenols	M	M	M	M	M										
Precipitation				M	M										
pH	D	D	D	D	D	M	M	M	M	M	M	M	M	M	
Temperature	D	D	D	D	D	M	M	M	M	M	M	M	M	M	
Flow			See Note 2			M	M	M	M	M					
Conductivity	D	D	D	D	D	M	M	M	M	M	M	M	M	M	
Level												See Note 3			M

NOTES: 1) Frequency of data sampling is coded: D for daily average continuous sampling; M for monthly samples. Precipitation meausrement are not taken at stations WU07 or WU61.

2) Daily at the three major stations (WU07, WU42, WU61), monthly at all others.

3) Monthly - all stations.

identified in Table 8.3-2. Collection frequency for those parameters coded with D is continuous; hourly averages are reported in the CB data reports. Daily averages and peaks calculated from the hourly averages are used in the time-series plots for these variables. Daily totals are plotted for those parameters coded with a T.

8.3.4.4 Noise

Noise is measured in decibels. Class I Indicator Variables, shown in Table 8.3-3, are peak measurements of noise level for daytime (0700 through 1900 hours) and for nighttime (1900 through 0700 hours).

8.3.4.5 Biology

Much of the biological data collection is accomplished seasonally or annually. These data and analyses are important indicators of possible oil shale development environmental impacts. However, under the definition of Class I Indicator Variables, a much smaller set of biological environmental parameters are identified. These parameters and their collection frequencies are shown in Table 8.3-3. The collection frequency of microclimate data is twice monthly and is indicated by 2M in this table. Monthly and weekly collection frequencies are shown in the table with M and W, respectively.

8.3.5 Action Levels

An action level is that magnitude of an indicator variable or its trend which triggers systems dependent monitoring (as defined in Section 8.1). These action levels are:

1. Where standards exist, such as NAAQS for air and NPDES for water, they will govern as the action levels, where appropriate.

TABLE 8.3-2

Air Quality and Meteorology Class I Indicator Variables

Variable		AB24	AA23	AB23	AB26	AB28	AREA
							Sampling Stations
SO_2		D		D	D		
H_2S		D		D	D		
O_3		D		D	D		
NO_x		D		D	D		
NO_2		D		D	D		
CO		D		D	D		
Particulates	(every 4th day)	T		T	T		
WS - 10m		D	D				
WD - 10m		D	D				
WS - 30m			D				
WD - 30m			D				
WS - 60m			D				
WD - 60m			D				
RH				D	D		
Temp - 10m		D		D			
Pressure				D			
Solar Radiation				T			
Temp - (60m - 10m)			D				
Precipitation				T	T	T	
Visual Range	(every 6th day in spring and fall)						VR

NOTES: Frequency of sampling is continuous for all variables except particulates and visual range. Daily averages with min and max hourly values are plotted for those variables coded with D. Daily totals are plotted for those coded with T.

TABLE 8.3-3

Noise Class I Indicator Variables

Variable	Sampling Station	
	NB01	NB15
Daytime Noise (0700-1900)	P	P
Nighttime Noise (1900 - 0700)	P	P

NOTES: Continuous sampling of noise is conducted for 24-hours every sixth day. The peak db level for two 12-hour intervals is designated here as P.

TABLE 8.3-4

Biology Class I Indicator Variables

Variable	Microclimate Stations			USGS			Piceance	Traffic		
	BC01	BC09	BC12	WP01	WP02	WP03	Cr. Road	BT01	BT02	BT03
Precipitation	2M	2M	2M							
Snow Depth	2M	2M	2M							
Temp. Max	2M	2M	2M							
Temp. Min.	2M	2M	2M							
Periphyton Bioproductivity				M	M	M				
Deer Road Counts							W			
Deer Road Kills							W			
Traffic Counts								W	W	W

NOTES: Microclimate data are collected twice monthly (2M); Periphyton bioproductivity collected monthly (M); and Deer and Traffic are counted weekly (W).

8.3 Indicator Variables

2. For all Class I indicator variables, short-term (within one year) trends will be examined by linear regression techniques to stated levels of significance. For air and water these will be 5%. For biology, the only Class I variables are those associated with microclimate; for these the level of significance will be 5%.

3. For annual averages obtained from all Class I variables and for selected Class II variables, long-term trends over the period of record will be examined by linear regression techniques to stated levels of significance. These are:

    a. Air & Water, Microclimate, and Wildlife 5%

    b. Vegetation 10%

4. In Items 2 and 3 the level of significance for which a trend could be indicated will also be stated.

5. For Items 2 and 3 above, where the trend over time is of "large" magnitude, the action level is judged to be exceeded. "Large" will be mutually determined by CB and the OSPO on a case-by-case basis.

8.3.6 Data Analysis Techniques

Data analysis techniques have been developed for each discipline, relevant to monitoring objectives.

8.3 Indicator Variables

Data collected during the baseline and subsequent monitoring periods have been entered into and maintained in a computer data base. Analyses techniques utilize the computer to select the appropriate data and to execute computerized statistical models in performing the analyses.

Table 8.3-5 presents a summary of the analytical techniques used in data analysis. Shown in the table are the statistical problem, data screening techniques approprate to the selection of a method of analysis, the tests that normally apply to the problem, the level of significance for accepting or rejecting the hypothesis, and the null hypothesis tested. The relevant techniques in each specific discipline are discussed in each subsequent section.

TABLE 8.3-5

Summary of Monitoring Plan Analytic Techniques

NUMBER	STATISTICAL PROBLEM	DATA SCREENING	STATISTICAL TEST	LEVEL OF SIGNIFICANCE	HYPOTHESIS TESTED
1	Comparison of a population mean to a baseline	Normal Population, Independent Random Samples, Outliers	T or W-Test	$\alpha = 0.05$	H_0: The mean is not different from the baseline
2	Comparison of two population means	Normal Population, Independent Random Samples, Equal Variances, Outliers	T or U-Test	$\alpha = 0.05$	H_0: There is no difference in population means between stations
3	Comparison of two means when the analysis of variance null hypothesis is rejected	Normal Populations, Independent Random Samples, Equal Variances, Outliers	Newman-Keuls (q-Test)	$\alpha = 0.10$	H_0: There is no difference in means between stations
4	Comparison of more than two means or population distribution functions	Normal Populations, Independent Random Samples, Equal Variances, Outliers	F-Test or 2-sided K-sample Smirnov Test	$\alpha = 0.05$	H_0: There is no difference in the population means or the population distribution functions are identical
5	Comparison of two proportions or ratios	Binomial Populations, Independent Random Samples, Equal Variances, Outliers	T-Test	$\alpha = 0.10$	H_0: There is no difference in proportions or ratios between stations
6	Comparison of more than two proportions or ratios	Binomial Populations, Independent Random Samples, Equal Variances, Outliers	F-Test	$\alpha = 0.20$	H_0: There is no difference in proportions or ratios between stations
7	Comparison of sample distribution of proportions to expected distribution of proportions		Log-likelihood ratio (nominal data)	$\alpha = 0.10$	H_0: The distribution of sample proportions is no different than expected
8	Relative Measure of diversity of observed attribute or phenomena		Shannon Index of Diversity	N/A	NA: Relative measures of predictability of Phenomena
9	Correlation between two variables	Outliers, X & Y are both random variables & have a joint distribution	T-Test	$\alpha = 0.05$	H_0: The observed value of one variable is independent of the other variable
10	Partial correlation between three or more variables	Outliers $X_1, X_2, X_3 \ldots X_n$ are all random variables & have a joint distribution	T-Test	$\alpha = 0.05$	H_0: The observed correlation between some variables explained by high dependence on some other variable
11	Determination of trend over time	Outliers, Residuals or Independent & $N(0, \sigma^2)$	T or F-Test	$\alpha = 0.05$	H_0: The slope of the equation that best fits the data is zero
12	Tabulation of data in summary form		None	N/A	N/A
13	Scatter diagrams of observed data		None	N/A	N/A
14	Histograms comparing several summary parameters		None	N/A	N/A
15	Graphs displaying parameters as a function of time		None	N/A	N/A
16	Special		None	N/A	N/A
17	Maps		None	N/A	N/A
18	Frequency or density comparison over time	Independent Random Samples Outliers	W or Sign Test	$\alpha = 0.05$	H_0: No change has occured in frequency or cover over time
19	Special purpose photo		None	N/A	N/A
20	Tri-Linear Diagrams		N/A		N/A
21	Linear Regression (Single/Multiple)		N/A	$\alpha = 0.05$	N/A
22	Professional judgement		None	N/A	N/A

8.0 DEVELOPMENT MONITORING PLAN

8.4 Tract Imagery

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.4 Tract Imagery

8.4.1 Surface Imagery

8.4.1.1 Scope

8.4.1.1.1 Previous Phase

Section 1 (C) of the Environmental Lease Stipulations requires that the Lessee conduct monitoring programs to measure perceptible changes from baseline conditions. Toward this end, both surface and remote aerial imagery were utilized from baseline to 1981; the Tract imagery program was discontinued in the Interim Monitoring period from 1981 to present. For the surface program, color photos were obtained annually at 35 photo points and color infrared photos were taken in the vicinity of the springs and seeps during the previous Development Monitoring phase.

8.4.1.1.2 Proposed Changes In Scope

Two reductions in program scope are proposed:

1) Elimination of the color infrared (CIR) program in vicinity of springs and seeps. Previously a CIR pan was taken two times throughout the growing season around 9 spring-and-seep locations to qualitatively record vigor. This program is judged to be of limited usefulness, partly because of irrigation withdrawals from some of the springs. Also, color photos (i.e., not CIR) can provide a visual record of changing conditions at their present locations.

2) A reduction in the number of stations for the surface color photography network is proposed from 35 to 18. Figure 8.4-1 shows both the previous and proposed network. It is felt that such reduction with the remaining strategic locations can still provide an adequate record of visual conditions in the Tract vicinity.

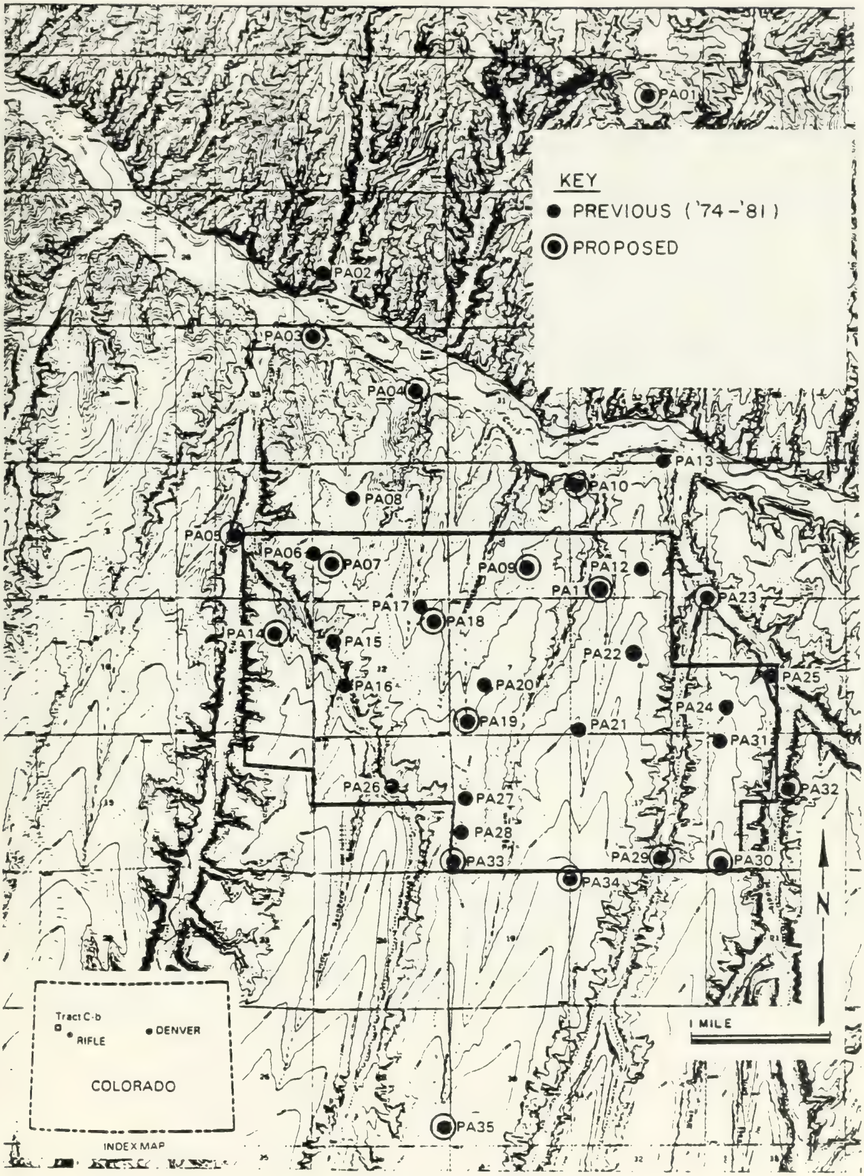


FIGURE 8.4-1
SURFACE COLOR PHOTOGRAPHY NETWORK

8.4 Tract Imagery

For a long range objective. as Landsat ground resolution improves as new sensors become available, Landsat probably can replace all other monitoring imagery with only minimal ground truthing by conventional imagery if needed.

8.4.1.2 Objectives

The objectives of the surface program are to qualitatively provide:

1) a visual record of changes from conditions existing prior to development operations;
2) visual evidence of successional changes in the ecosystem;
3) a visual record of surface disturbance;
4) an historic account of surface development.

8.4.1.3 Experimental Design

Eighteen points have been selected for Development Monitoring from which a 360° pan is photographed in color on a yearly basis, (Figure 8.4-1). A 35mm camera with an f 1.8, 55mm lens is used. Once each year in June, a 360° photo pan is taken from each of the stations.

8.4.1.4 Archiving Methods

A complete set of the 35mm color slides for all photo points is numbered as to station, aspect and date. This set is stored in plastic envelopes and bound in a 3-ring binder, then filed in the CB library as a part of the permanent record of the Project. No quantitative analyses of these data are planned.

8.4 Tract Imagery

8.4.2 Remote Imagery

8.4.1.2 Objectives

The objectives of the remote imagery program are to provide:

1) a record of changes from conditions existing prior to development;
2) a qualitative inventory of site physical conditions;
3) a measure of vegetation conditions over a selected portion of the Piceance Creek Basin;
4) a measure of vegetation condition change over a growing season and over years.

8.4.2.2 Methods of Analyses

Objectives 1) and 2) above will be accomplished primarily through aerial photography. Objectives 3) and 4) above will be accomplished primarily through remote sensing obtained from the Landsat family of Earth-resources satellites.

8.4.2.2.1 Aerial Photography

Vertical views of black and white photographs will be obtained at a scale of 1:7200 once in the summer every three years (1985, 1988, etc.). Flight lines will be established to provide at least 50% sidelap and fore-and-aft overlap. Existing ground control points will be visible on Tract section corners. Resolution is such that an object 3' across can be seen with the unaided eye. (The 1980 maps at this scale show 5 foot contour intervals; resolution should be good to one-half the contour interval.)

Prints shall be archived in the CB library as part of permanent records of the Project. Yearly values of disturbed and reclaimed acreages will continue to be estimated from direct measurements, drawings, and photographs, as previously done.

8.4.2.2.2 Landsat Imagery

This technique utilizes the Landsat Earth-resources satellite in a sun-synchronous orbit coupled with appropriate ground-truth measurements. Since the satellite is in a sun-synchronous orbit, it passes over the area at the same local time each day, significant since it precludes changes in shadowing which would influence reflectance. Land coverage to date utilized the multispectral sensor (MSS) and is approximately 110 X 110 square miles. This on-board MSS sensor measures spectral reflectance in four discrete bands:

Band	Wavelength (um)	
4	0.5 to 0.6	Green
5	0.6 to 0.7	Red
6	0.7 to 0.8	Photo IR
7	0.8 to 1.1	Photo IR

Its ground resolution is approximately 79 X 79 square meters.

Landsat D was launched in July 1983; it contains both an MSS and a new sensor called a thematic mapper (TM). The TM has a ground resolution of 30 X 30 meters and operates in the spectral bands shown on Table 8.4-1.

It is expected that in 1985 when the TM is fully operational that it will be utilized for the CB application; it is preferred over the MSS primarily because of its improved ground resolution. That is, it is proposed to restart the Landsat program in the summer of 1985.

The paragraphs to follow discuss deriving both change detection techniques and vegetation indices from information in the Landsat bands; it is illustrated for the MSS, since it has been previously used.

TABLE 8.4-1

Thermal Mapper (TM) Spectral Data

Band	Spectral Range, um	Radiometric Resolution	Principal Application
1	0.45 to 0.52	0.8% NE	Coastal water mapping. Soil/vegetation differentiation. Deciduous/coniferous differentiation.
2	0.52 to 0.60	0.5% NE_p	Green reflectance by healthy vegetation.
3	0.63 to 0.69	0.5% NE_p	Chlorophyl absorption for plant species differentiation.
4	0.76 to 0.90	0.5% NE_p	Biomass surveys. Water body delineation.
5	1.55 to 1.75	1.0% NE_p	Vegetation moisture measurement. Snow/cloud differentiation.
6	10.4 to 12.5	0.5K NETD	Plant heat stress measurement. Other thermal mapping.
7	2.08 to 2.35	2.4% NE_p	Hydrothermal mapping.

NE_p = noise equivalent reflectance

NETD = noise equivalent temperature difference

Source: Landsat-D Brochure.
General Electric Company,
Lanham, MD

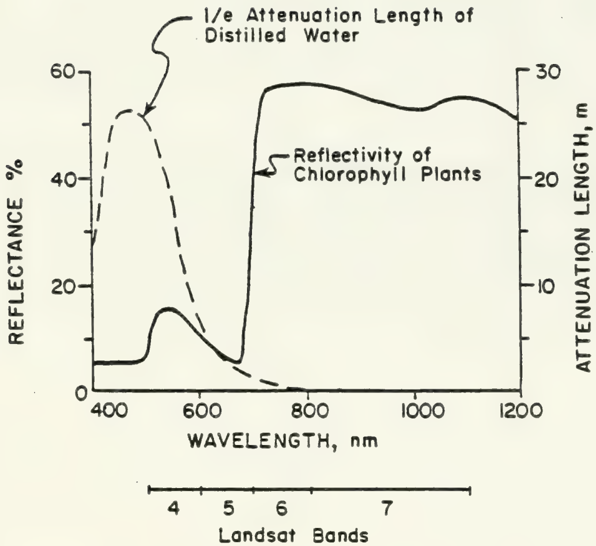


FIGURE 8.4-2
LANDSAT REFLECTANCE vs. WAVELENGTH

8.4 Tract Imagery

Two important factors determining leaf reflectance are the light absorbing pigments within the leaf and the physical structure of the leaf. The pigments (chlorophylls, xanthophylls, carotenoids, and anthocyanins) are responsible for absorption of energy in the visible wavelengths, but they do not interact with infrared (IR) energy (see Figure 8.4-2). The structure of the leaf is important to both visible absorptance and IR reflectance. Leaf structure increases the effective path length within the leaf for the visible and IR wavelengths. This increases the opportunity for the interception of radiation by the pigments and results in the upward scattering of 40-60 percent of the near IR energy intercepted by the leaf.

Previous work has shown that various combinations of red and near-IR reflectance or radiance bear a close relationship to biomass, leaf area index, leaf water and other vegetation canopy parameters. The IR/RED ratio as a vegetation index has been used to derive a leaf area index for canopies, for mapping the primary productivity of shortgrass prairies, and for assessing biomass. This background-normalizing aspect of vegetation indices has been further indicated by Maxwell, et al (1980).

The results of an initial study in 1979 verified the feasibility of using Landsat vegetation indices to monitor biomass changes in the chained pinyon-juniper rangelands and in the hay meadows along the Piceance Creek. The normalized differences or vegetation index (VI) derived from Landsat bands 7 and 5 was shown to be most useful for this application. This index is computed according to the equation:

$$VI = \left(\frac{b - a}{b + a} + 1\right) 125 \qquad \text{Equation (1)}$$

Where a = the digital number recorded for MSS band 5 (0.6 to 0.7 um),
b = the digital number recorded for MSS band 7 (0.8 to 1.1 um),
and the other numbers are constants which keep VI values within a 0 to 225 range for normal conditions.

8.4 Tract Imagery

It should be emphasized that these indices respond only to green vegetation and they must be at the appropriate time of the year. Senescent (brown) vegetation is spectrally similar to bare ground and cannot be distinguished by Landsat imagery.

A field sampling or ground-truth program was initiated in May, 1980 and continued through September, 1980. The sampling dates were chosen to correspond with Landsat overpasses. Ten sample transects were established; five each in the Piceance Creek meadows and the upland ridges (chained pinyon-juniper areas). One-square-meter sampling quadrats were used on the ridges and 2000 cm^2 quadrats were employed in the meadows. A double sampling procedure was used to obtain biomass values for the quadrats that were randomly placed within the ten sample transects. Ocular estimates of biomass were made for each quadrat, and the green vegetation in every fifth quadrat was clipped and weighed. Approximately ten quadrat samples were taken for each transect. Results of this sampling are depicted on Figure 8.4-3.

Data were extracted from the Landsat Computer Compatible Tapes (CCT's) for each of the 10 field sites for each image date. The normalized difference index was computed according to equation (1) and the results were plotted on Figure 8.4-4. The mean index value from Landsat for each site is plotted vs. the average measured biomass at that site. This curve is known as the calibration curve.

To obtain the above referenced vegetation index data the CCT's are processed and displayed as follows:

Software exists for extracting data for the test area from the Landsat Computer Compatible Tapes (CCT's), which is the first step in image processing. The next step in processing is to transform the data via systematic geometric corrections for Earth rotation and scanner mirror velocity, then to rotate the

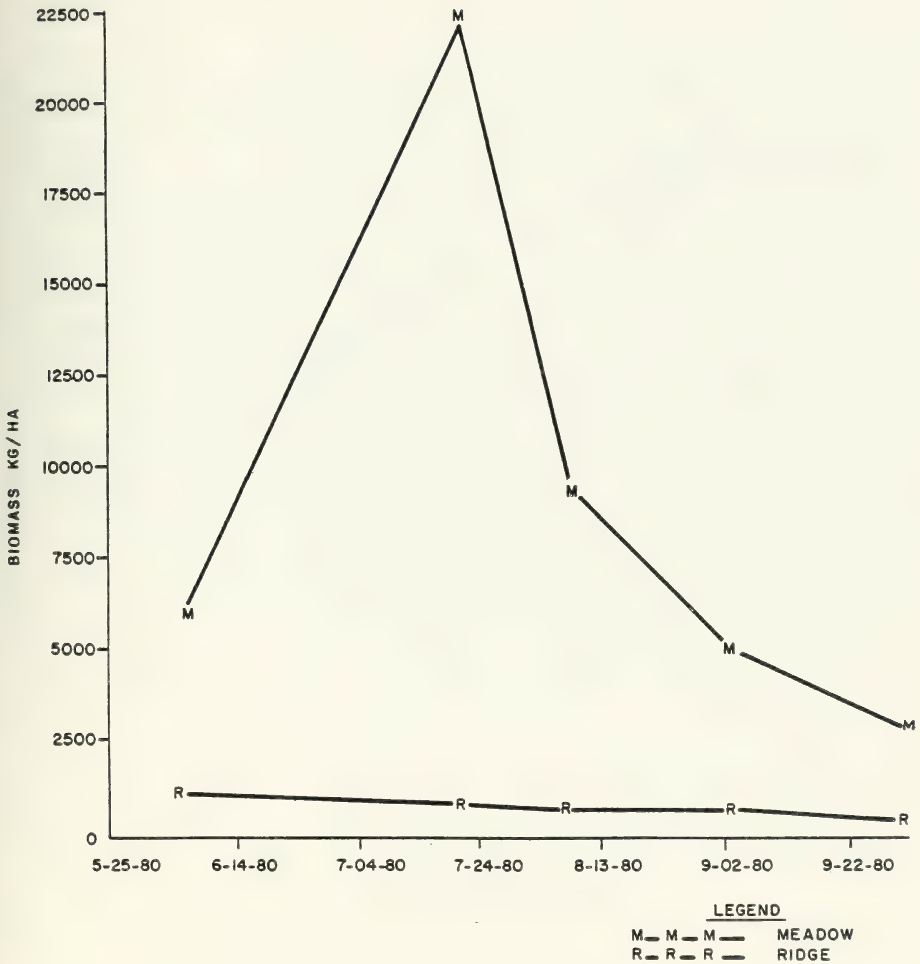


FIGURE 8.4 - 3

MEASURED (GROUND TRUTH) BIOMASS VS. DATE

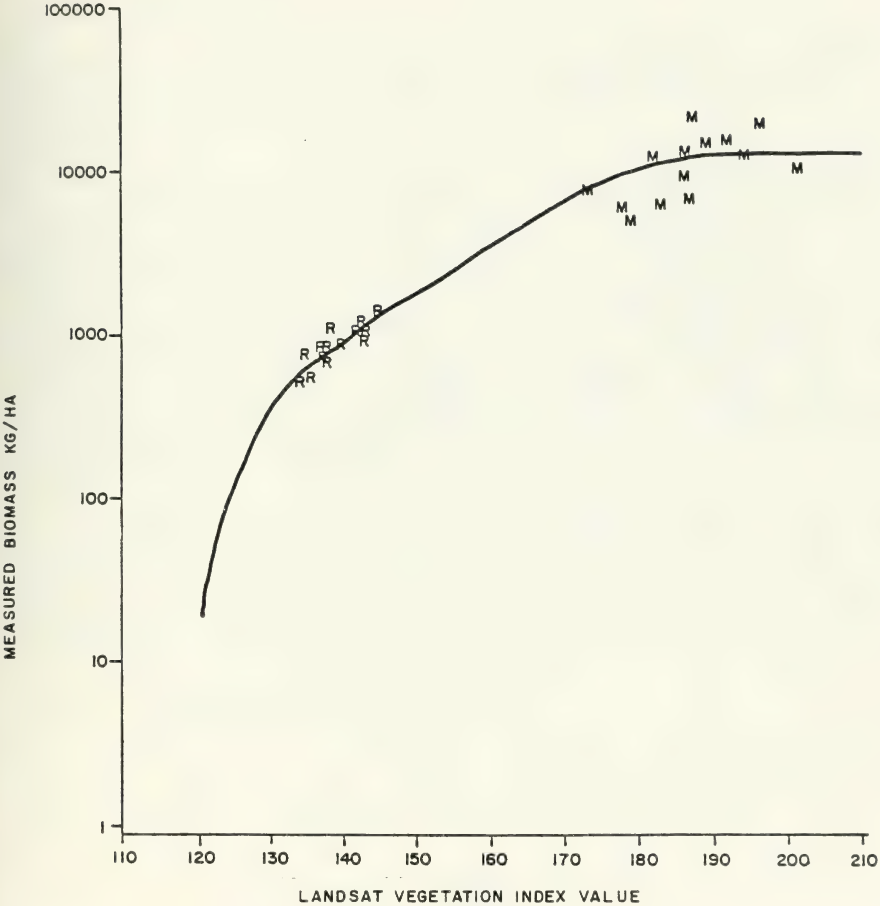


FIGURE 8.4-4

MEASURED BIOMASS VS. LANDSAT VEGETATION INDEX

image to true north and scale it to 1:24,000 to precisely match the scale of USGS topographic maps. Geometric accuracy is approximately plus or minus one resolution unit (pixel).

Once geometrically controlled, filtering (as in next paragraph) was then performed on each data set for each channel, and the vegetation index for each data set was computed and added to that data set as a fifth channel of information. The data sets were then merged for comparison and differencing of the vegetation index was performed. A histogram of difference values was generated and used to select a threshold for mapping intensity of change. These intensity-of-change values in both positive and negative directions were displayed via line printer output as gray-scale maps. The Landsat data for each channel are similarly presented.

To reduce the "salt-and-pepper noise" and enhance the quality of the digital Landsat data two filtering algorithms were considered: a moving average or low pass filter and a minimum variance filter. These are described in the 1981 CB Annual Report. The minimum variance filter was selected.

8.4.2.3 Experimental Design Utilizing Landsat

With the previous operational satellite system utilizing Landsats 2 and 3, coverage of satellite Path 38, Row 32 at the Tract exists every nine days. In 1980, for example, in the growing season overflight dates were:

June 5, 14, 23
July 2, 11, 20, 29
August 7, 16, 25
September 3, 12, 21, 30

From these potential imagery dates nominally 2 to 4 clear-weather dates were selected for data aquisition and analysis. Through 1980, eight image dates were

selected for this analysis: June, 1977; August, 1977; June, 1979; August, 1979; June, 1980; July, 1980; August, 1980; and September, 1980. The vegetation index is calculated for each of the selected dates at selected locations. Differences in the vegetation index either at two dates in the growing season or between years for the same month is called change detection and is obtainable for the selected time spans. Since Landsat D is in a different orbit its coverage is different and imagery dates will be selected in the future.

Six areas were designated as areas of concern:

1. Riparian area below discharge point.
2. Riparian area above discharge point.
3. Chained pinyon-juniper area for maximum effects.
4. Sprinkler system area of influence for irrigation, initiated in June, 1980.
5. Control areas for possible dewatering effects and sprinkler system influence.
6. General condition of the disturbed area surrounding the Service, Production, and Ventilation Escape Shafts.

The location of the test area and the six areas of concern are shown in Figure 8.4-5.

To gain some appreciation of use of the vegetation index to obtain change-detection results, Figure 8.4-6 presents a typical gray map of the vegetation index for the June, 1977 image date. Additionally, Table 8.4-2 is a summary of both between-years and seasonal change for each study site. The information included in this table is:

1. Mean index value for each site.
2. Percent change in the means using the image date in the first column as a reference.

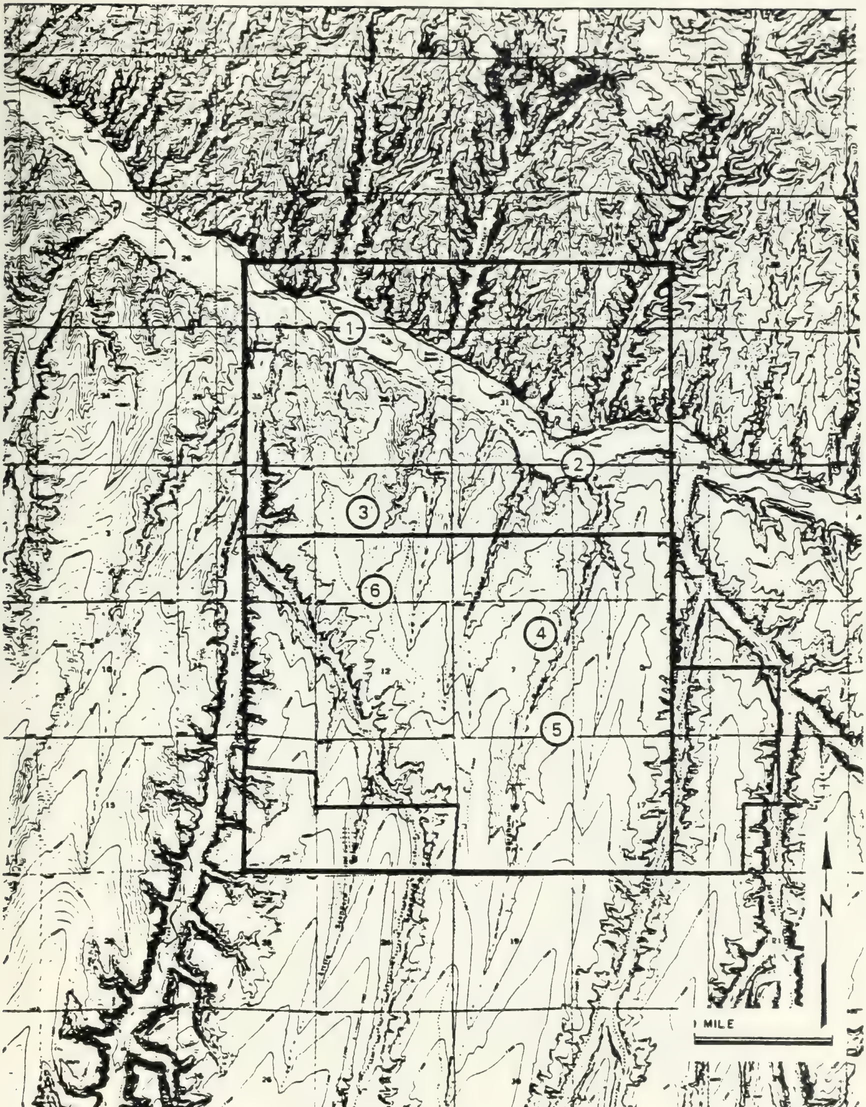


FIGURE 8.4-5
LANDSAT TEST AREA AND SIX AREAS OF CONCERN

THE CHARACTER SET USED FOR DISPLAY IS
GREEN BIOMASS (KG/HA)

FROM	0.00	TO	90.00	DISPLAYED	W	0 (WATER)
FROM	91.00	TO	121.00	DISPLAYED		0 (BARE SOIL)
FROM	122.00	TO	125.00	DISPLAYED	.	0 - 175
FROM	126.00	TO	130.00	DISPLAYED	•	175 - 475
FROM	131.00	TO	137.00	DISPLAYED	•	475 - 900
FROM	138.00	TO	147.00	DISPLAYED	■	800 - 1525
FROM	148.00	TO	157.00	DISPLAYED	●	1525 - 2950
FROM	158.00	TO	169.00	DISPLAYED	*	2950 - 6300
FROM	170.00	TO	180.00	DISPLAYED	O	6300 - 10900
FROM	181.00	TO	191.00	DISPLAYED	θ	10900 - 13000
FROM	192.00	TO	202.00	DISPLAYED	●	> 13000
FROM	203.00	TO	213.00	DISPLAYED	●	> 13000
FROM	214.00	TO	256.00	DISPLAYED	■	> 13000

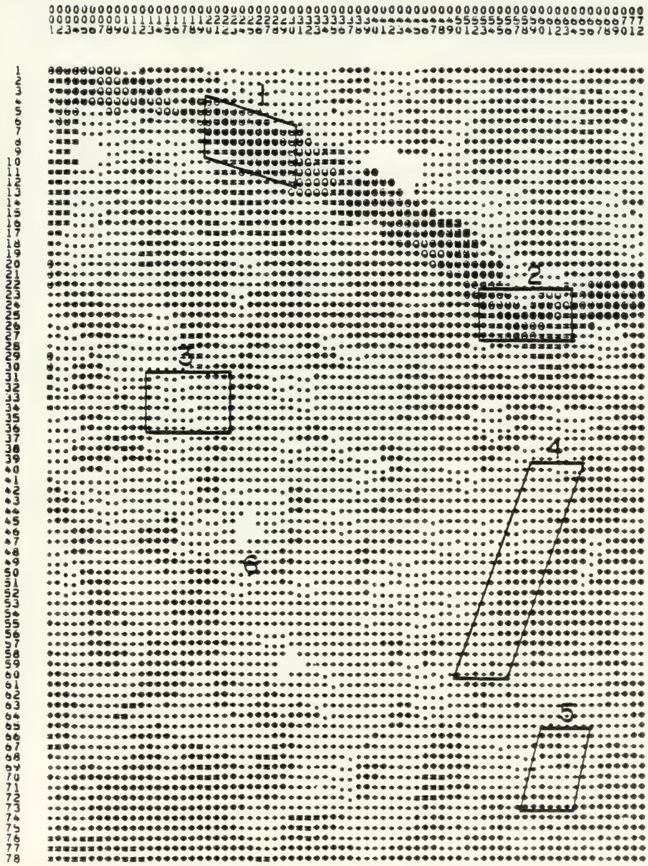


FIGURE 8.4-6

Graymap of the Vegetation Index (Normalized Difference). June, 1977 Image Date.

TABLE 8.4-2

Change Detection Summary

June 1977 - September 1980

Landsat Vegetation Index

	JUN 1977		AUG 1977		JUN 1979		JUN 1980	
SITE 1	186	***	166	-11%	190	+2%	177	-5%
	***	***	80	--	104	=	91	=
2	172	***	159	-8%	179	+4%	176	+2%
	***	***	87	--	108	+	105	+
3	127	***	122	-4%	132	+4%	142	+12%
	***	***	95	=	106	+	115	++
4	129	***	127	-2%	132	+2%	140	+9%
	***	***	97	=	102	+	110	+
5	130	***	127	-2%	CLOUD		144	+11%
	***	***	97	=			114	++
6	128	***	123	-4%	126	-2%	135	+5%
	***	***	96	=	99	=	107	+

	AUG 1977		AUG 1979		AUG 1980	
SITE 1	166	***	187	+13%	160	-4%
	***	***	121	+++	94	-
2	159	***	189	+19%	162	+2%
	***	***	130	+++	103	=
3	122	***	136	+11%	133	+9%
	***	***	114	++	111	++
4	127	***	137	+8%	135	+6%
	***	***	111	++	108	+
5	127	***	141	+11%	137	+8%
	***	***	114	++	110	+
6	123	***	129	+5%	129	+5%
	***	***	106	+	106	+

	JUN 1979		AUG 1979		JUN 1980	
SITE 1	190	***	187	-2%	177	-7%
	***	***	97	=	87	--
2	179	***	189	+6%	176	-2%
	***	***	110	+	97	=
3	132	***	136	+3%	142	+8%
	***	***	103	=	109	+
4	132	***	137	+4%	140	+6%
	***	***	106	+	108	+
5	CLOUD		CLOUD		CLOUD	
6	126	***	129	+2%	135	+7%
	***	***	103	=	108	+

	AUG 1979		AUG 1980	
SITE 1	187	***	160	-14%
	***	***	73	---
2	189	***	162	-14%
	***	***	73	---
3	136	***	133	-2%
	***	***	97	=
4	137	***	135	-1%
	***	***	98	=
5	141	***	137	-3%
	***	***	96	=
6	129	***	129	0
	***	***	100	=

	JUN 1980		JUL 1980		AUG 1980		SEP 1980	
SITE 1	177	***	189	+7%	160	+10%	190	+7%
	***	***	112	++	83	--	113	++
2	176	***	181	+3%	162	-8%	176	0%
	***	***	105	=	85	--	100	=
3	142	***	136	-4%	133	-6%	134	-6%
	***	***	94	-	91	-	93	-
4	140	***	136	-3%	135	-4%	139	-1%
	***	***	96	=	95	=	99	=
5	144	***	140	-3%	135	-5%	136	-6%
	***	***	96	=	93	-	92	-
6	135	***	131	-3%	129	-4%	131	-3%
	***	***	96	=	95	=	97	=

LEGEND

*** = NO VALUES (REFERENCE DATE)

MEAN INDEX VALUE	% CHANGE OF MEAN
MEAN INDEX VALUE AFTER DIFFERENCING	TYPE OF CHANGE

TYPE OF CHANGE:

--- NEGATIVE (STRONG)
-- NEGATIVE (MILD)
- NEGATIVE
= NO CHANGE
+ POSITIVE
++ POSITIVE (MILD)
+++ POSITIVE (STRONG)

8.4 Tract Imagery

3. Mean index value for each site after differencing.
4. Type of change associated with the differenced index value.

Note: Item 4 describes any significant change whereas item 2 describes any change in the means.

By comparing the June, 1977, June, 1979 and June, 1980 image dates, one can note a general increase in biomass from 1977 - 1980. This is to be expected since 1977 was a drought year; 1979 was closer to normal; and 1980 is considered a wet year. Later in the growing season of each year, comparisons show an increase in biomass from August, 1977 to August, 1979 and August, 1980, with a decrease shown from August, 1979 to August, 1980. This decrease could be due to length of the growing season, degree days during the growing season, or the total precipitation during the summer months. Results shown in Table 8.4-2 are supported by the maps of change detection in the appendix of the 1980 CB Annual Report.

Seasonal change detection is depicted by the comparisons of June vs. August 1977, June vs. August 1979 and June vs. July-September 1980. The uplands areas are characterized by a negative change except for 1979 which again indicates that August of 1979 was a high biomass month. The riparian areas are characterized by fluctuating changes between positive and negative changes. These fluctuations could be due to harvest of the hay fields.

8.0 DEVELOPMENT MONITORING PLAN

8.5 Hydrology and Water Quality

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PROGRAM

8.5 Hydrology and Water Quality

8.5.1 Introduction, Scope, and Purpose

8.5.1.1 Monitoring of Regulated Pollutants

A hydrologic monitoring program has been implemented to provide water quantity and quality data to determine if changes occur, and if changes are detected, to determine whether the changes are natural or caused by development of the C-b Tract. Streams, springs, seeps, and water in the alluvium, and bedrock aquifers have been monitored under requirements of the Lease since baseline. Additionally, water quality parameters are monitored in the discharge from Ponds A and B under requirements of the NPDES permit; water quality parameters are measured in Piceance Creek to compare with the current (Class II Warm Water Agricultural and Recreation) stream standards set by the State of Colorado. The program was expanded in 1979 to accommodate monitoring required by the Water Augmentation Plan and Court Decree (W3492) which includes monitoring of water pumped from shafts and the mine as it is developed, and substantial additional monitoring of springs, wells, and precipitation stations. Quality assurance procedures are required by the EPA and are discussed in Section 8.14.

The simplified two-layer aquifer concept that guided the measurements of flows, levels, and water quality parameters during the baseline and earlier monitoring program has been replaced by the more complex system discussed in Section 2.3 and shown in Figure 2.3-8. The UPC2 and LPC3 intervals include the zone planned for retorting. This zone will be dewatered during mining operations.

Several deep wells have now been recompleted according to the more complex aquifer system. Details of the well recompletions have been provided to OSPO in the 15 July 1981 Development Monitoring Report No. 6. Discussion of the monitoring program has been separated into two parts: quality of water (Levels and Flows) and Water Quality.

It is to be noted that additional geohydrologic measurements may be instituted as indicated from the effort to project groundwater flow patterns associated with post-abandonment of MIS retorts.

8.5 Hydrology and Water Quality

8.5.1.2 Rationale for Monitoring Unregulated Pollutants

Referring to the Water Quality Control Plan, Sub-section 6.4, principle effluent sources (distinct from process, re-cycled waste streams) are the NPDES discharge, processed shale pile and MIS spent retorts. Water quality parameters associated with NPDES are, of course, requlated. Previously groundwater monitoring parameters were regulated by a state subsurface disposal permit which was repealed in 1981. In that regard, of the long list of parameters measured, experience and analysis screened the list down to a small number of most useful parameters. These are:

TDS	Phenols	
Total Alkalinity	HCO_3/CO_3	(ratio)
Kj - N	$\frac{Na + K}{Ca + Mg}$	(ratio)
NH_3 - N		
TOC		

These parameters, including those in the ratios, are currently being monitored in the water quality monitoring program at Tract C-b. It is expected that this same list would be useful to monitor in the leachate, if any, from the processed shale pile. Input water to this pile and leachates from it will also be analyzed for organics and trace metals per the rationale discussed in Process Monitoring (Section 8.13).

8.0 DEVELOPMENT MONITORING PROGRAM

8.5 Hydrology and Water Quality

8.5.2 Levels and Flows

8.5.2.1 Streams

8.5.2.1.1 Introduction and Scope

As many as eighteen stations on or near C-b Tract have been operated and maintained by the USGS Water Resources Division. Currently (during Interim Monitoring) eight are operational. From July 1984, ten are proposed for resumption of Development Monitoring.

Figure 8.5-1 is a map of the Tract showing the locations of nearby surface water monitoring stations included in the environmental monitoring program; historical stations and those proposed for Development Monitoring are shown. Remote stations are shown in Figure 8.5-2. Operational timelines for all stations are shown in Figure 8.5-3. Station utility and location are delineated on Table 8.5-1.

The hydrographs recorded to date show the seasonal influences of runoff, evapotranspiration, and irrigation diversions. About 65 percent of the irrigation diversions occur in the late spring and early summer (April to July). 30 percent of the diversions occur in late summer and early fall (August to October). These diversions are apparent in the hydrographs, but the timing of diversions is inconsistent from year to year as a result of natural variability in the moisture regime.

8.5.2.1.2 Objectives

The surface stream monitoring program has been implemented to attempt to determine the range of variability in streamflow that occurs at the USGS stations. Additionally, streamflow data are analyzed for the existence of trends and Project impacts, if any.

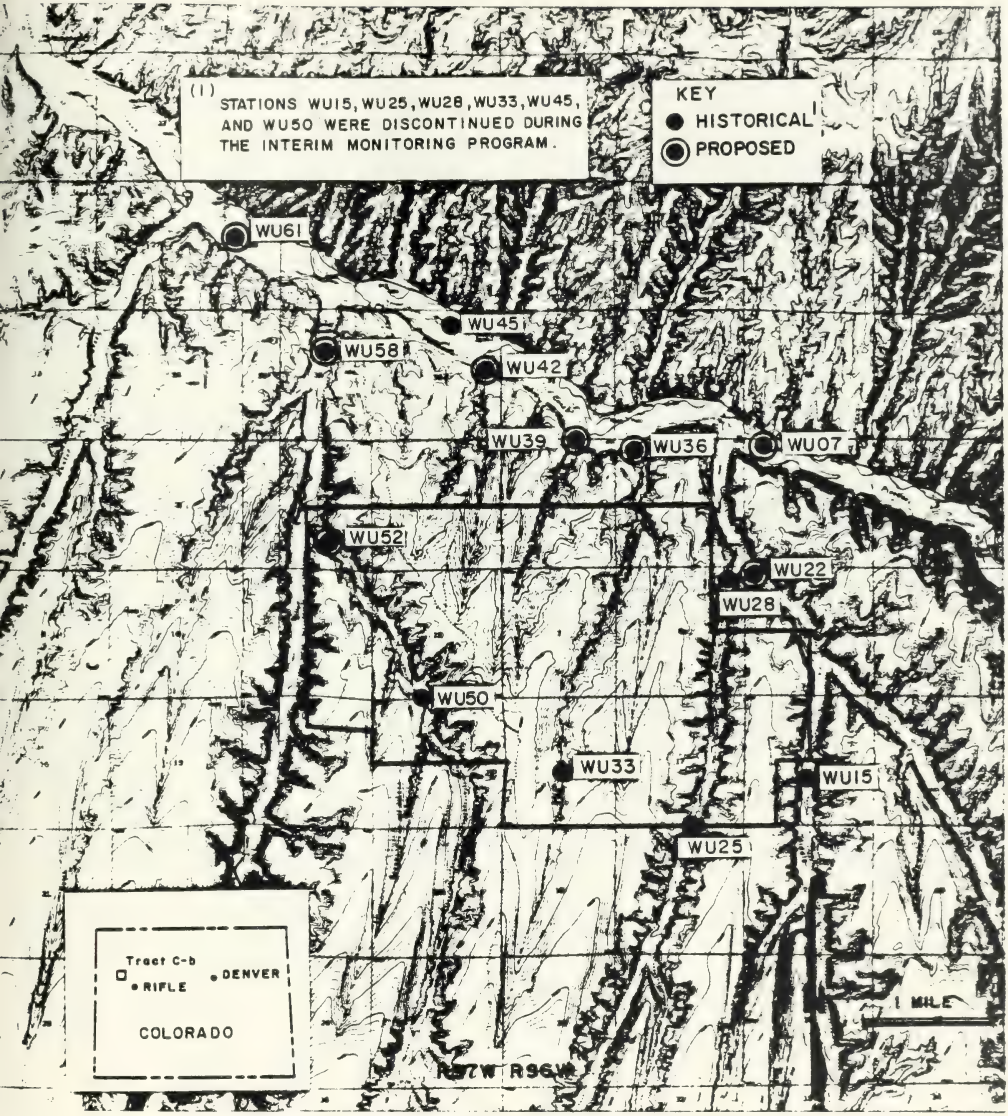


Figure 8.5-1 NEAR-TRACT STREAM GAUGING STATION MONITORING NETWORK

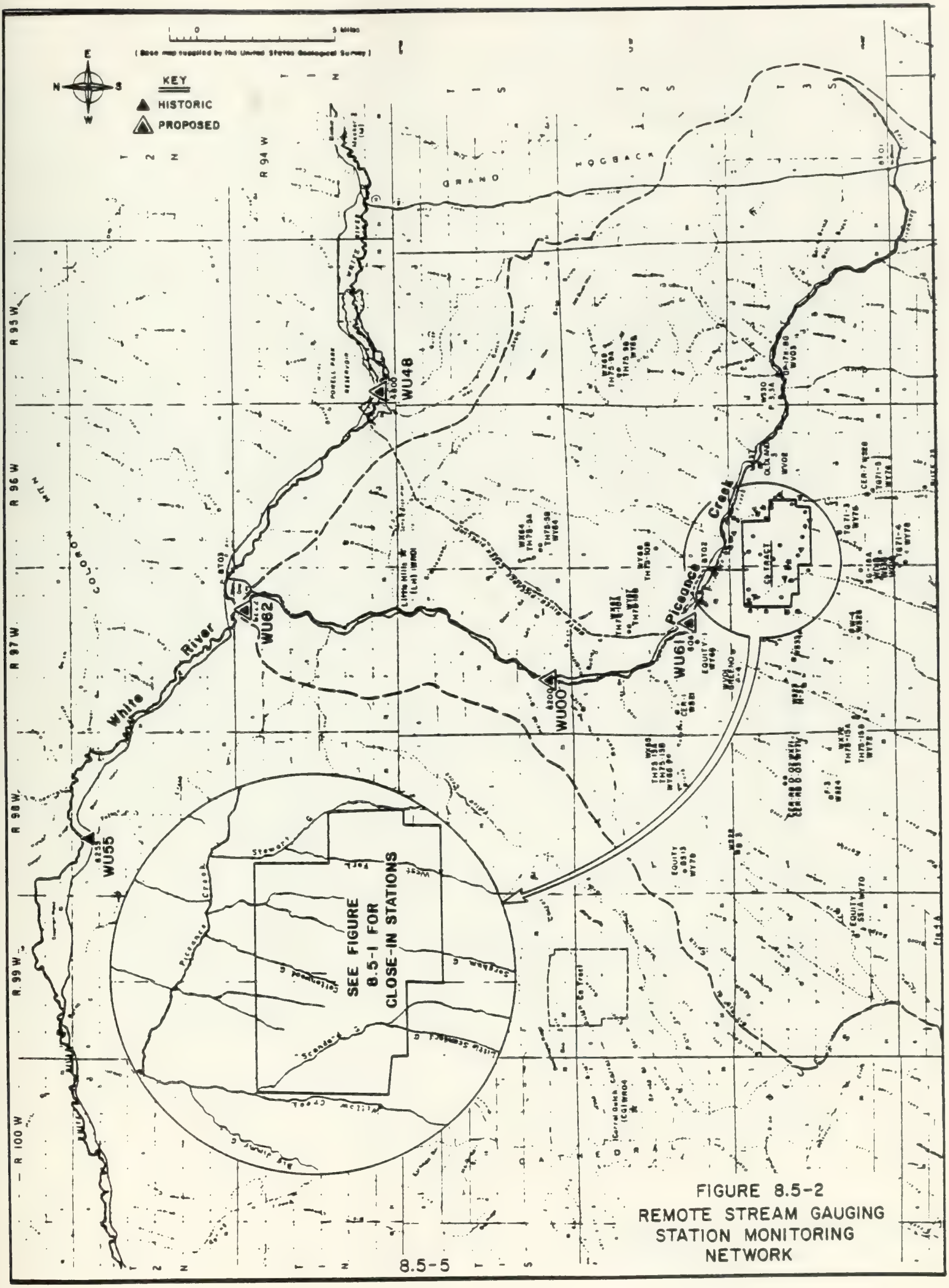


FIGURE 8.5-2
REMOTE STREAM GAUGING
STATION MONITORING
NETWORK

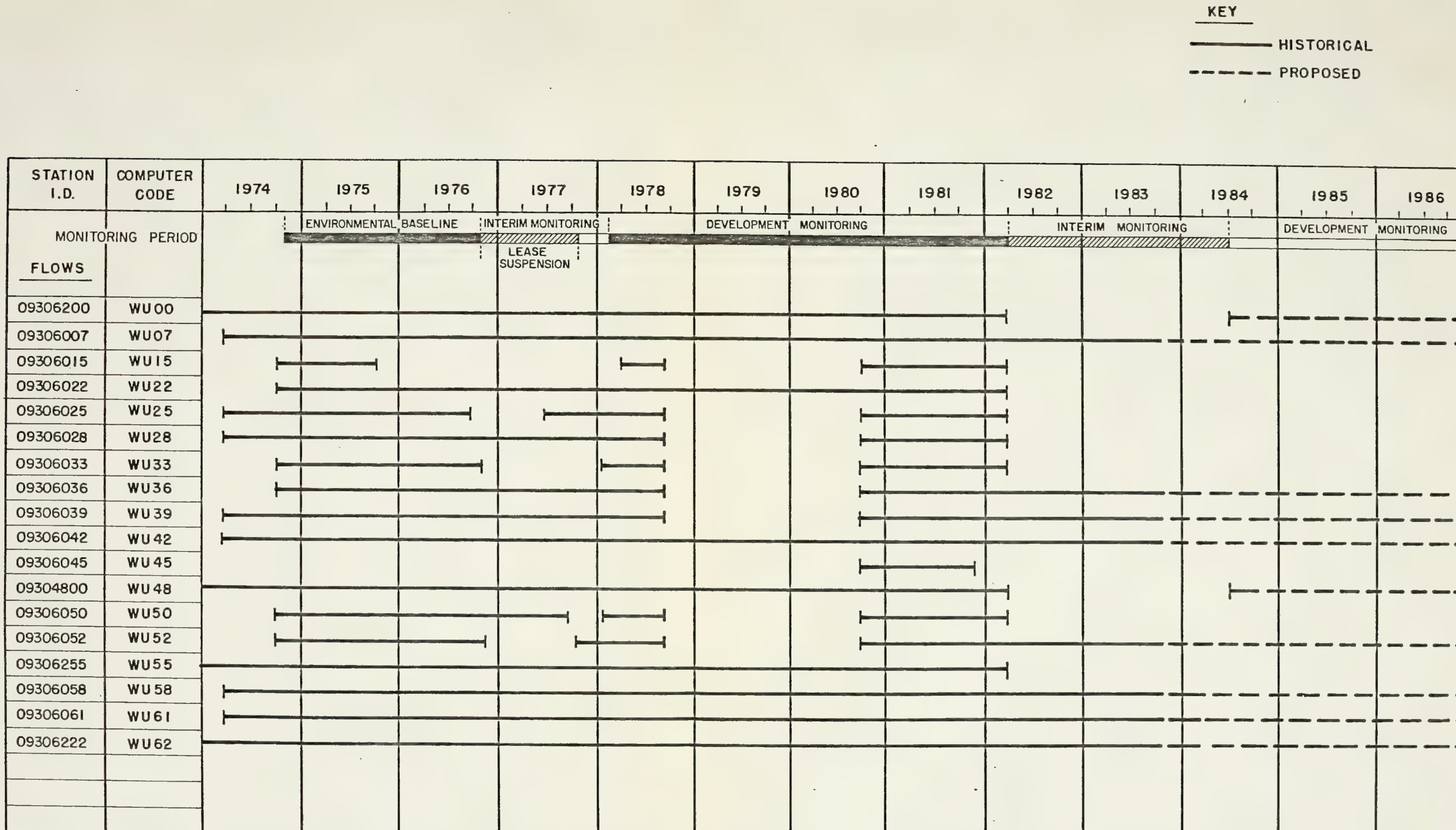


Fig. 8.5-3 STREAM GAUGING STATION OPERATIONAL TIME LINES FOR FLOWS

TABLE 8.5-1

Stations of the Surface Water Monitoring Program (Historical and Planned)

Computer Code	USGS Number	Status C P*	Station Location	Comments
WU00	09306200	P	Piceance Creek near Ryan Gulch	Once of the major monitoring stations on Piceance Creek. Flow data since October 1964. Terminated in Interim Monitoring; proposed for Development Monitoring.
WU07	09306007	C P	Piceance Creek below Rio Blanco, upstream from C-b Tract	To operate during the life of the Project. Data since April 1974, a major station. Continuous flow measurements.
WU15	09306015		In Middle Fork Stewart Gulch	Intermediate operation since October 1974. Ephermal Station. Proposed to remain terminated.
WU22	09306022	C P	Stewart Gulch	Current station; data since October 1974; proposed for Development Monitoring.
WU25	09306025		In West Fork Stewart Gulch	Intermediate operation since April 1974. Ephermal Station. Proposed to remain terminated.
WU28	09306028		At mouth of West Fork of Stewart Gulch	Intermediate operation since April 1974. Proposed to remain terminated.
WU33	09306033		In Sorghum Gulch, upstream	To monitor runoff from construction activities. Intermediate operation since October 1974. Ephemeral Station. Proposed to remain terminated.
WU36	09306036	C P	At mouth of Sorghum Gulch	To monitor runoff from Project activities. Intermediate operation since April 1974. Ephemeral Station. Proposed for Development Monitoring.
WU39	09306039	C P	At mouth of Cottonwood Gulch	To monitor stream runoff from surface facilities, ore storage piles, roads and construction areas. Ephemeral Station. Intermediate data since April 1974; current sta; Proposed for Development Monitoring.
WU42	09306042	C P	In East No Name Gulch west of Cottonwood Gulch	Used to monitor discharge under NPDES permit. Ephemeral Station. Data since April 1974. Major current sta; proposed for Development Monitoring.
WU45	09306045		Piceance Creek 50 meters downstream from East No Name Gulch and Piceance Creek confluence	New station constructed to monitor discharges from C-b Tract through East No Name Gulch. Terminated.
WU48	09304800	P	White River below Meeker	Station required by Water Augmentation Plan. Proposed for Development Monitoring.
WU50	09306050		In Scandard Gulch, upstream	Intermediate Operation since October 1974. Ephermal Station near southern boundary of C-b. Proposed to remain terminated.
WU52	09306052	C P	At mouth of Scandard Gulch	Intermediate data since October 1974. Ephemeral Station. Current sta; proposed for Development Monitoring.
WU55	09306255		Yellow Creek near White River	Station required by Water Augmentation Plan. Seeking to terminate monitoring.
WU58	09306058	C P	Willow Creek	Current Station; Proposed for Development Monitoring.
WU61	09306061	C P	Piceance Creek at Hunter Creek, downstream from C-b Tract	To operate during the life of the Project. Data since April 1974, a major station. Continuous flow measurements.
WU62	09306222	P	Piceance Creek at White River	Station required by Water Augmentation Plan. Proposed for Development Monitoring.

*C = Current Station
P = Proposed for Development Monitoring (July 1984)

8.5.2.1.3 Experimental Design

Network status is delineated in Table 8.5-1 regarding current and proposed stations; continuous flow measurements are made.

Streamflow data will be analyzed by comparison between total and mean annual flows, comparing ratios of flows from different stations, and by identification of the existence of trends over time.

8.5.2.2 Springs and Seeps

8.5.2.2.1 Introduction and Scope

The flow from natural springs and seeps provides a substantial fraction of the volumetric low-level stream flows to Piceance Creek. The source areas for the springs and the hydrologic relationships are imperfectly known. Although none of the springs studies are actually on the C-b Tract, all are close enough that they may or may not be affected by significant changes in the groundwater system caused by mining activities.

Through the baseline phase, flow data were obtained from nine springs located on the west and east boundary of the Tract and along Piceance Creek. The current configuration is shown on Figure 8.5-4. Monitoring of additional springs was initiated to comply with the Water Augmentation Plan as shown on Figure 8.5-5. Figure 8.5-6 shows the operational timelines for springs and Table 8.5-2 shows the sample schedule for flow measurements of the springs and seeps and current status.

With regard to analysis of springs data three related items are of special interest:

1) The interrelationship of springs data with precipitation events;

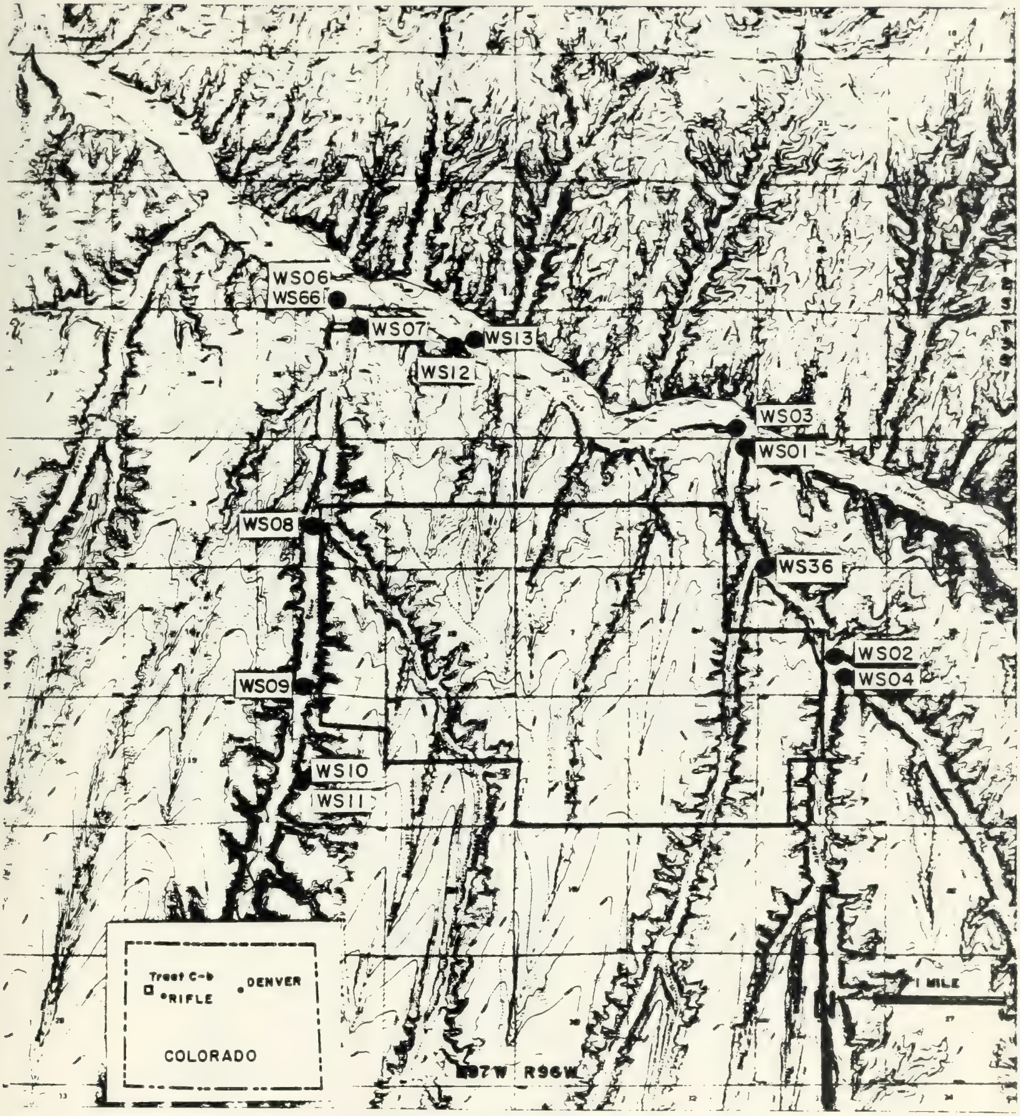


Figure 8.5-4 NEAR-TRACT SPRINGS AND SEEPS MONITORING NETWORK

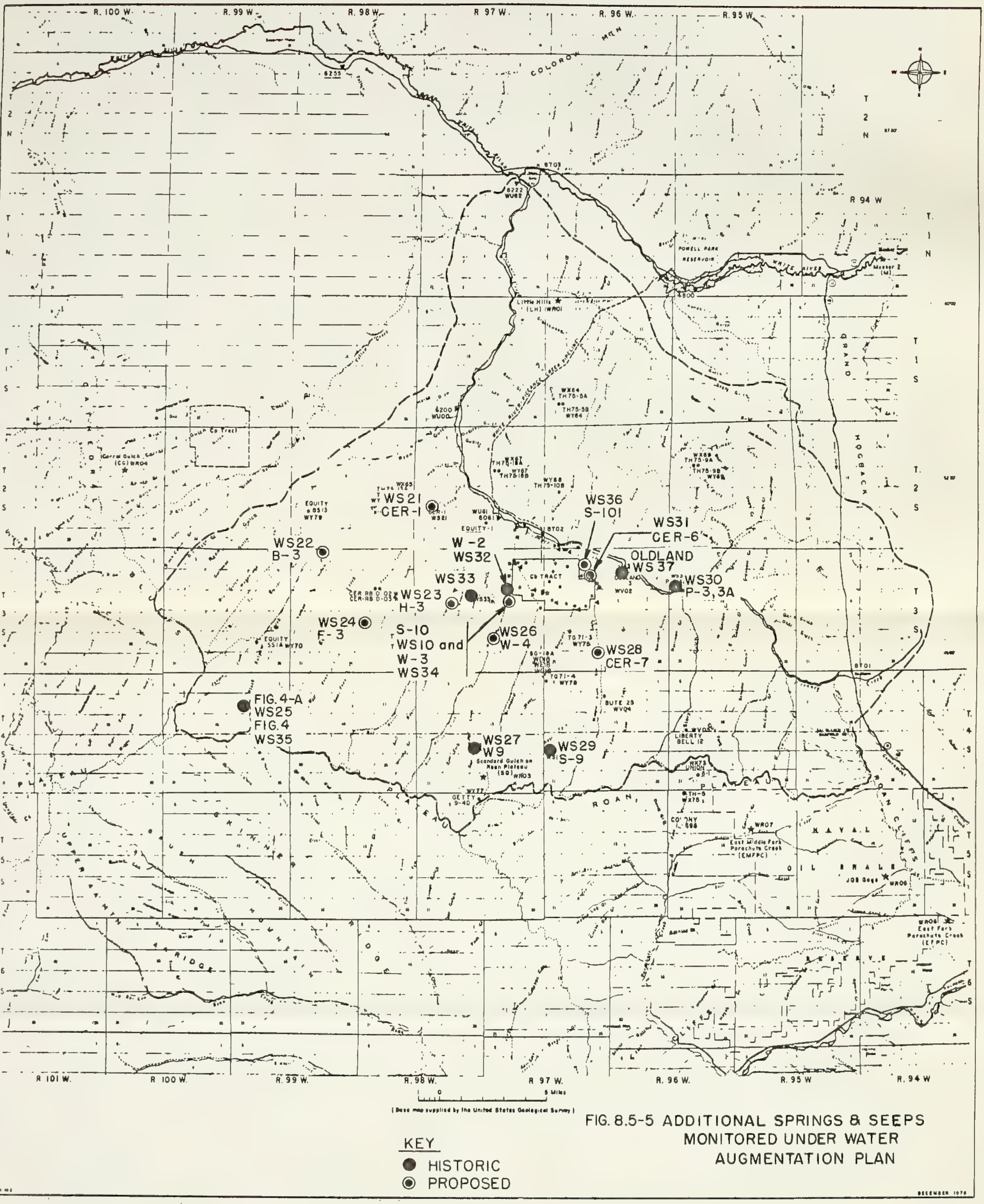
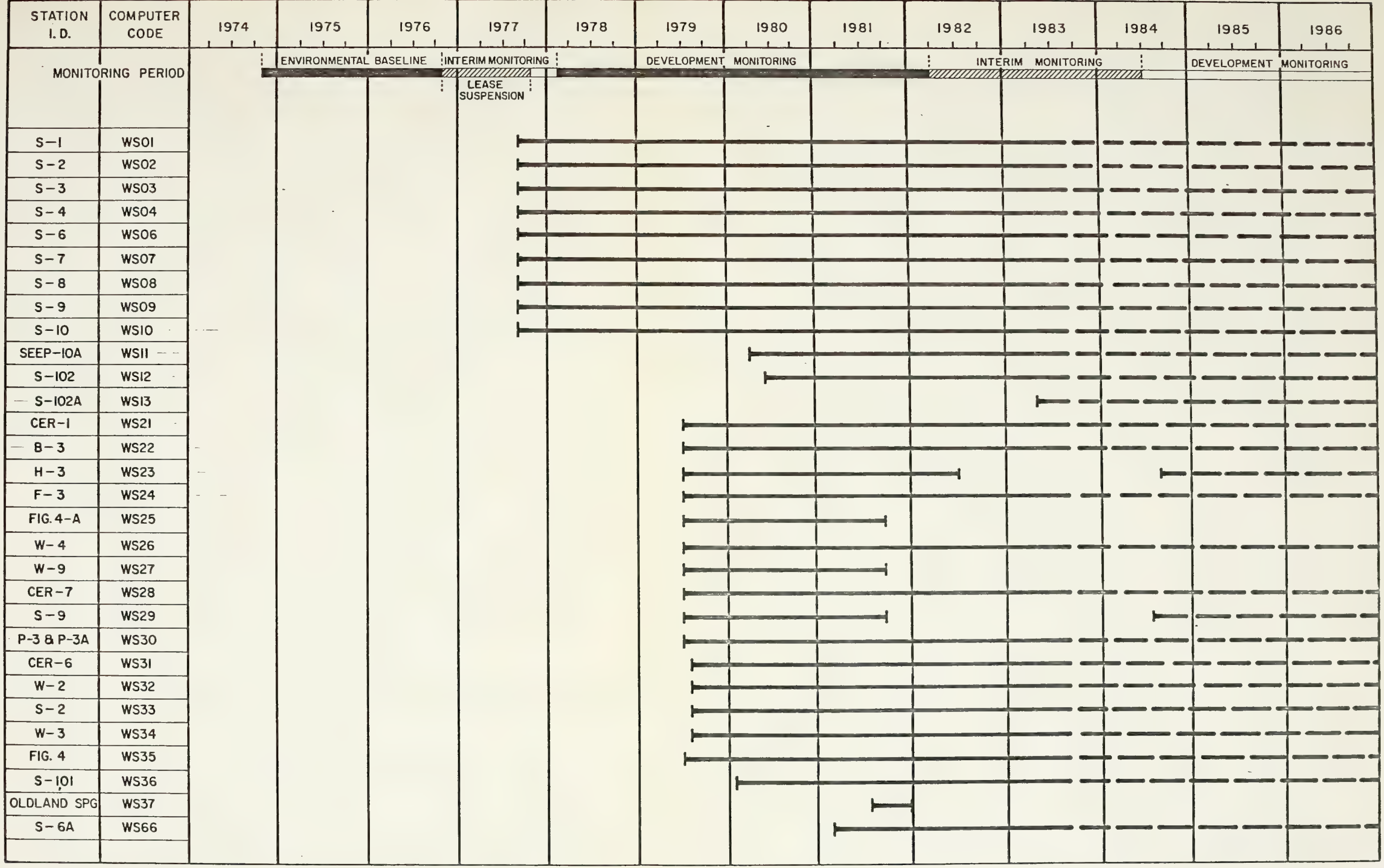


FIG. 8.5-5 ADDITIONAL SPRINGS & SEEPS MONITORED UNDER WATER AUGMENTATION PLAN



KEY

HISTORICAL

PROPOSED

Fig. 8.5-6 SPRINGS AND SEEPS OPERATIONAL TIME LINES FOR FLOWS

TABLE 8.5-2

Springs and Seeps Status and Sampling Schedule

Computer Code	Designation	Status C P	Frequency Discharge	Frequency Water Quality	Measured By
WS01	CB S-1	C P	M/D	M/D	A
WS02	CB S-2	C P	M	M	A
WS03	CB S-3	C P	M/D	M/D	A
WS04	CB S-4	C P	M	M	A
WS05	CB S-6	C P	M	M	A
WS66	CB S-6A	C P	M	M	A
WS07	CB S-7	C P	M	M	A
WS08	CB S-8	C P	M	M	A
WS09	CB S-9	C P	M/D	M/D	A
WS10	CB S-10	C P	M/D	M/D	A
WS11	CB SEEP A	C P	M/D	M/D	A
WS12	CB S-102	C P	M	M	A
WS13		C P	M	M	A
WS21	CER-1	C P	Q	-	WRD
WS22	B-3	C P	Q	-	WRD
WS23	H-3	P	Q	-	WRD
WS24	F-3	C P	Q	-	WRD
WS26	W-4	C P	Q	-	WRD
WS28	CER-7	C P	Q	-	WRD
WS30	P3 & P3A	C P	Q	-	WRD
WS31	CER-6	C P	Q	-	WRD
WS33	S-2	C P	Q	-	WRD
WS34	W-3	C P	Q	-	WRD
WS36	CB S-101	C P	M	M	A

Code: M = Monthly
Q = Quarterly
A = Applicant (C-b Tract)
M/D = Monthly if not diverted
WRD = Water Resources Division of the USGS
C = Current Station
P = Proposed for Development Monitoring (July 1984)

2) Attempt to establish whether or not the springs flows have passed through the deep bedrock;

3) Particularly in the region down-dip of Tract operations (i.e., in the region near the confluence of East No Name Gulch and Piceance Creek) attempt to establish if the upper Uinta aquifer is being recharged.

The items 2) and 3) suggested an integrated approach to springs, alluvial and bedrock wells in this confluence area including use of fluoride as an indicator, since its magnitude is depth dependent.

8.5.2.2.2 Objectives

The objectives in monitoring the flows from springs and seeps are: to establish the range of variability in flows, to establish interrelationships of springs and seeps to precipitation events, to investigate the existence of trends in flows, due to environmental effects and to further define orgins of springs waters with regard to bedrock.

8.5.2.2.3 Experimental Design

Flows from springs and seeps will be measured monthly or quarterly as indicated on Table 8.5-2. Data will be compared with precipitation data to determine if correlations exist. Seasonal variations will be examined as will mean annual flows, and the existence of short or long term linear trends will be investigated. Further insights into springs origin will be attempted.

8.5.2.3 Alluvial Wells

8.5.2.3.1 Introduction and Scope

Fourteen alluvial wells were drilled in the gulches at C-b Tract and in the major drainages of Piceance Creek, Willow Creek, and Stewart Gulch. These wells were sampled through the baseline period and will be used for monitoring during development of C-b Tract. An additional well (WA56) was added in 1980; WA21 and WA22 near the new spring S-102 were drilled in 1983. The locations of the seventeen alluvial monitoring wells are shown on Figure 8.5-7; operational timelines indicated on Figure 8.5-8. Network status and sampling schedule are shown on Table 8.5-3. It is to be noted that well A-5A (WA55) is periodically dry, which accounts for discontinuity in sampling, shown on Figure 8.5-8.

Measurements obtained to date show that the yearly range in levels is about five feet, with maximum levels in summer and minimum levels in winter and early spring. The spatial distribution of the alluvial wells and the analysis of plots of the water levels indicate no apparent effects of mine dewatering. Significant decreases in piezometric levels in some bedrock wells are accompanied by no change or slight increases in proximal alluvial wells.

Alluvial well WA03 is the one most likely to be affected by dewatering if there were interaction between the deep aquifer and the alluvial aquifers, because it is nearest shaft dewatering and approximately aligned with the northwesterly extension of the cone of the depression. Levels in WA03 show a slight decrease since 1974 until August or September of 1978. Since then there has been a strong rising trend during the time of dewatering. This is a strong and dramatic statement of the lack of relationship between the deep aquifer and water levels in the alluvium. This subject has been discussed in Section 6.3.3 and specifically illustrated on the alluvial-bedrock well pair by lack of communication shown on Figure 6.3-2.

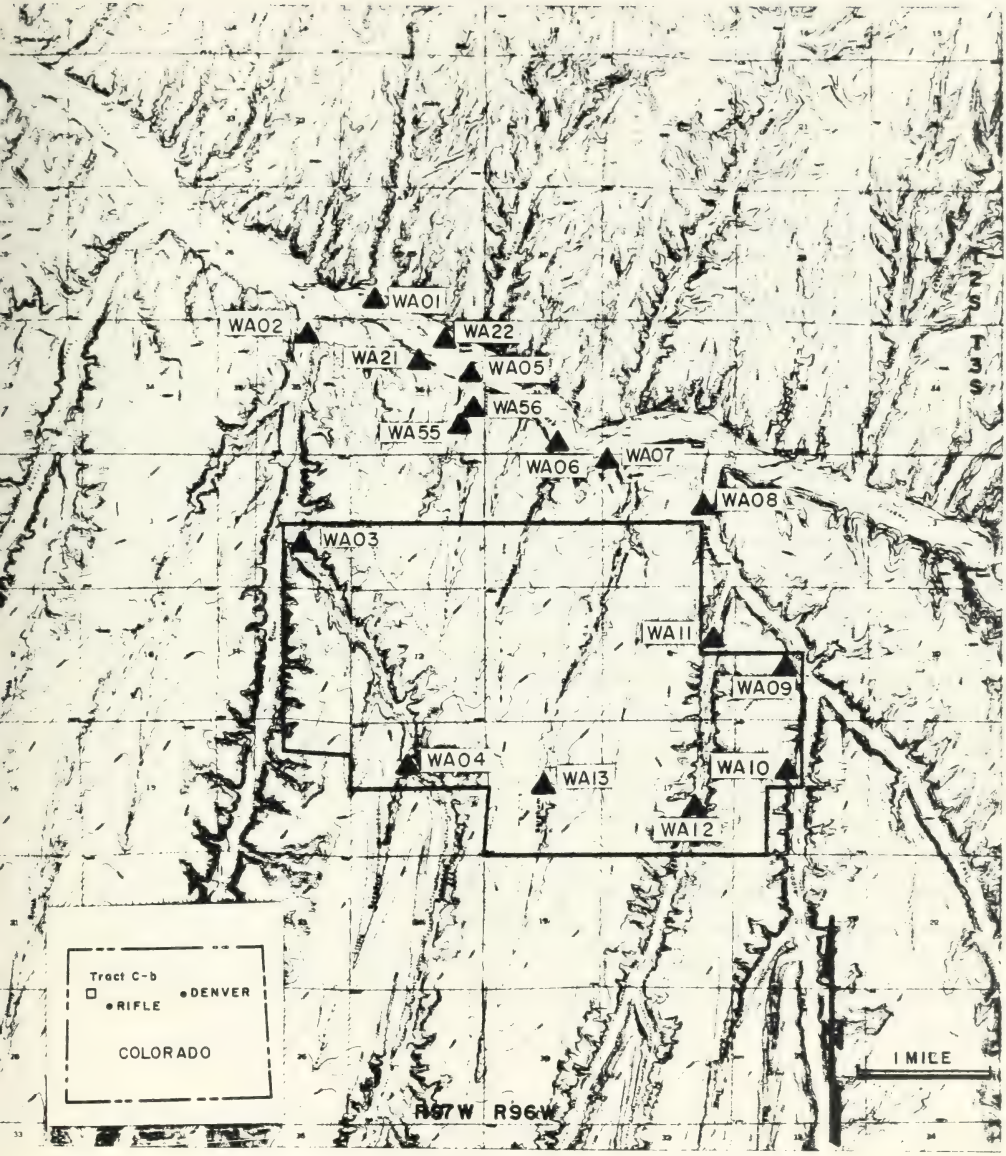


Figure 8.5-7 ALLUVIAL AQUIFER MONITORING NETWORK

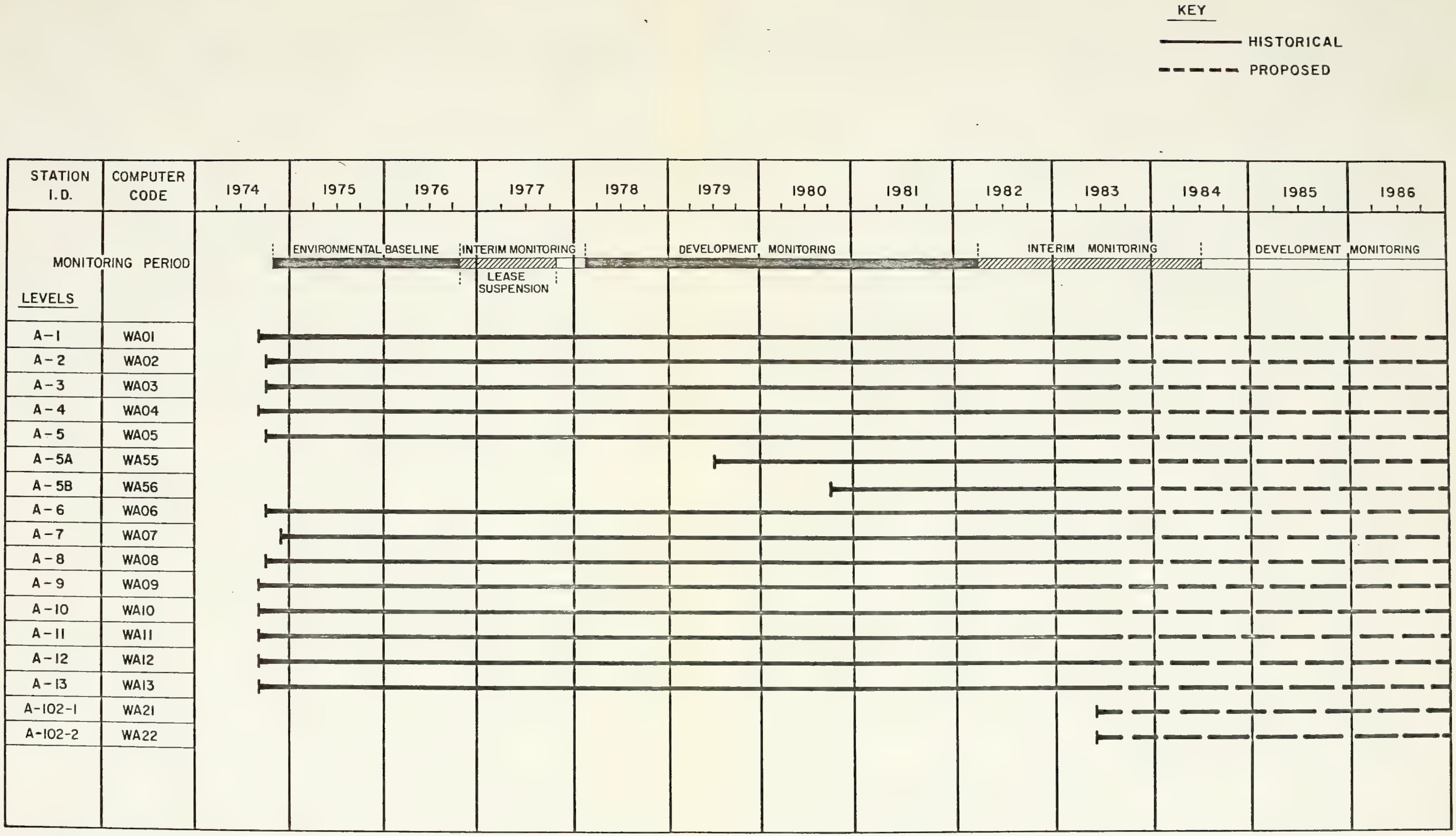


Fig. 8.5-8 ALLUVIAL WELLS OPERATIONAL TIME LINES FOR LEVELS

TABLE 8.5-3

Alluvial Wells Status and Sampling Schedule

Computer Code	Designation	Formation	Frequency Levels*	Water Quality C	Water Quality P	Measured By
WA01	A-1	Alluvium	M	S/F	S/F	A
WA02	A-2	"	M	S/F	S/F	A
WA03	A-3	"	M	S/F	S/F	A
WA04	A-4	"	Dry	S/F	S/F	A
WA05	A-5	"	M	S/F	QF	A
WA55	A-5A	"	M	S/F	QF	A
WA56	A-5B	"	M	S/F	QF	A
WA06	A-6	"	M	S/F	QF	A
WA07	A-7	"	M	S/F	S/F	A
WA08	A-8	"	M	S/F	S/F	A
WA09	A-9	"	M	S/F	S/F	A
WA10	A-10	"	Dry	S/F	S/F	A
WA11	A-11	"	M	S/F	S/F	A
WA12	A-12	"	M	S/F	S/F	A
WA13	A-13	"	Dry	S/F	S/F	A
WA21	A-102A	"	M	S/F	QF	A
WA22	A-102B	"	M	S/F	QF	A

*C and P

Code:
M = Monthly
S/F = Semi Annual Field Measurements
QF = Quarterly Field Measurements and Fluoride
C = Current (Interim Monitoring Program)
P = Proposed (Development Monitoring Program)
A = Applicant (C-b Tract)

8.5.2.3.2 Objectives

The objectives in monitoring alluvial wells are: to establish the range of variability in levels, to compare water levels in the alluvium during mine dewatering to investigate whether or not communication exists between deep aquifers and alluvial water, and to investigate possible correlation between alluvial well levels and streamflow.

8.5.2.3.3 Experimental Design

Monthly measurements of water levels in alluvial wells have shown no evidence that deep aquifers and alluvial waters are in communication. Three well pairs will continue to be studied to verify this over the long term:

Wells	Computer Code
WA07/SG-19	WA07/WD19
WA06/SG-20-3	WA06/WD20
WA03/SG-1-2	WA03/WD20

Alluvial well data will be analyzed for linear trends over time. Levels in alluvial well WA03 will be examined over time and compared with streamflow of WU61. Well SG-19 may require modification to improve the quality of measurements.

8.5.2.4 Bedrock Wells

8.5.2.4.1 Introduction and Scope

Bedrock wells are monitored in the following aquifers:

8.5 Hydrology and Water Quality

General Location	Aquifer	Associated Computer Code
Near/on-Tract	Uinta Formation	WC##
Near/on-Tract	Upper Parachute Creek 1 (UPC_1)	WD##
Near/on-Tract	Upper Parachute Creek 2 (UPC_2)	WE##
Near/on-Tract	Lower Parachute Creek 3 (LPC_3)	WG##
Near/on-Tract	Lower Parachute Creek 4 (LPC_4)	WH##
Remote, off-Tract	Upper Aquifer Zone	WX##
Remote, off-Tract	Lower Aquifer Zone	WY##

Strata to which these designations apply were discussed in Section 2.3 and shown on Figure 2.3-8. The deep well monitoring network near-Tract is depicted as follows:

Aquifer	Figures Showing Station Locations	Figures Showing Operational Timelines	Table Showing Status and Sampling Schedule
Uinta UPC_1 UPC_2	Figure 8.5-9	These are presented in the 6-month Data Reports	Table 8.5-4 (all wells)
LPC_3 LPC_4	Figure 8.5-10		
Upper Aquifer, Lower Aquifer, Composite Wells (Additional Bedrock Wells Monitored Under WAP)	Figure 8.5-11		

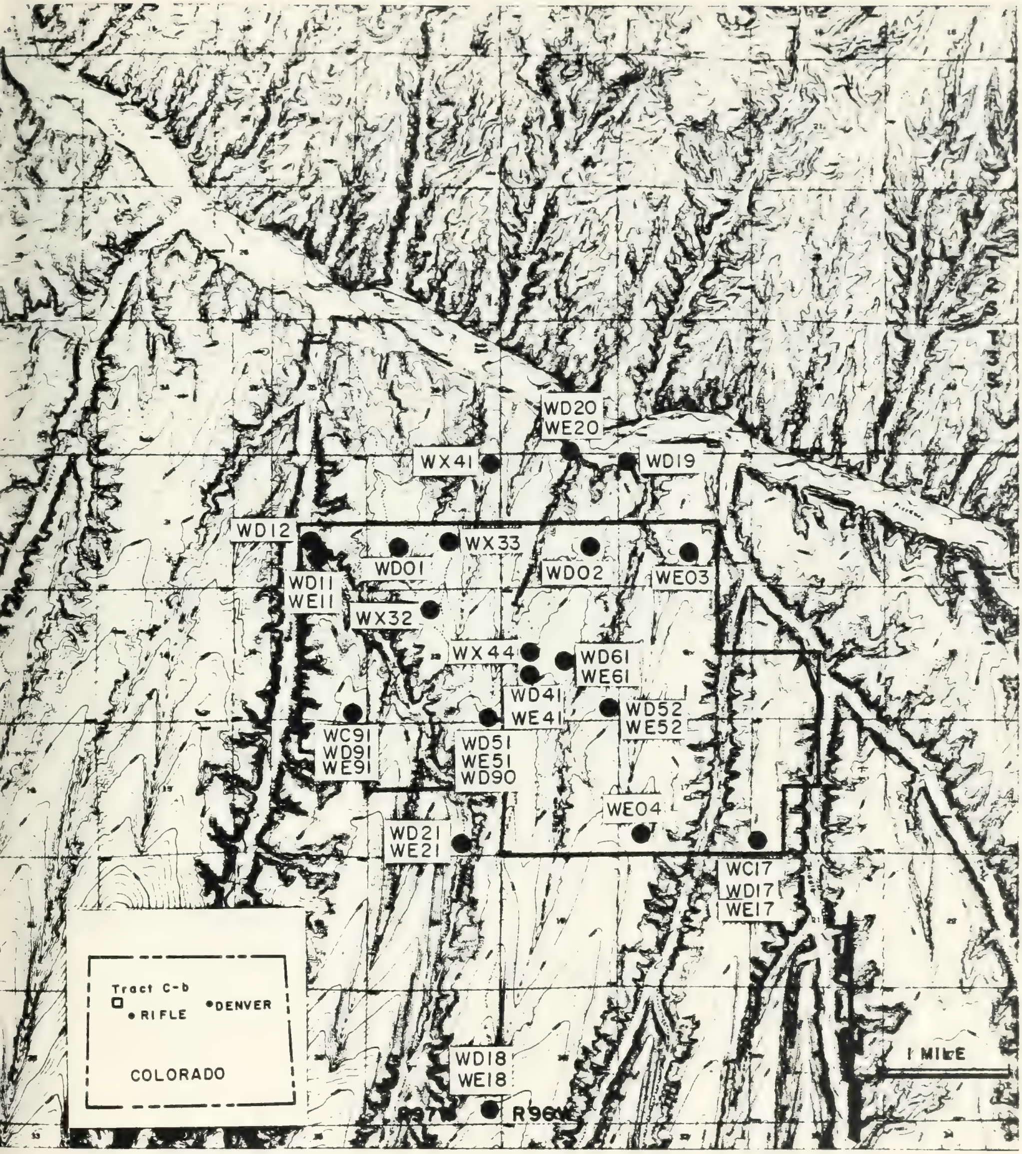


Figure 8.5-9 DEEP WELL MONITORING NETWORK NEAR C-b TRACT FOR UINTA, UPC_1 AND UPC_2 ZONES

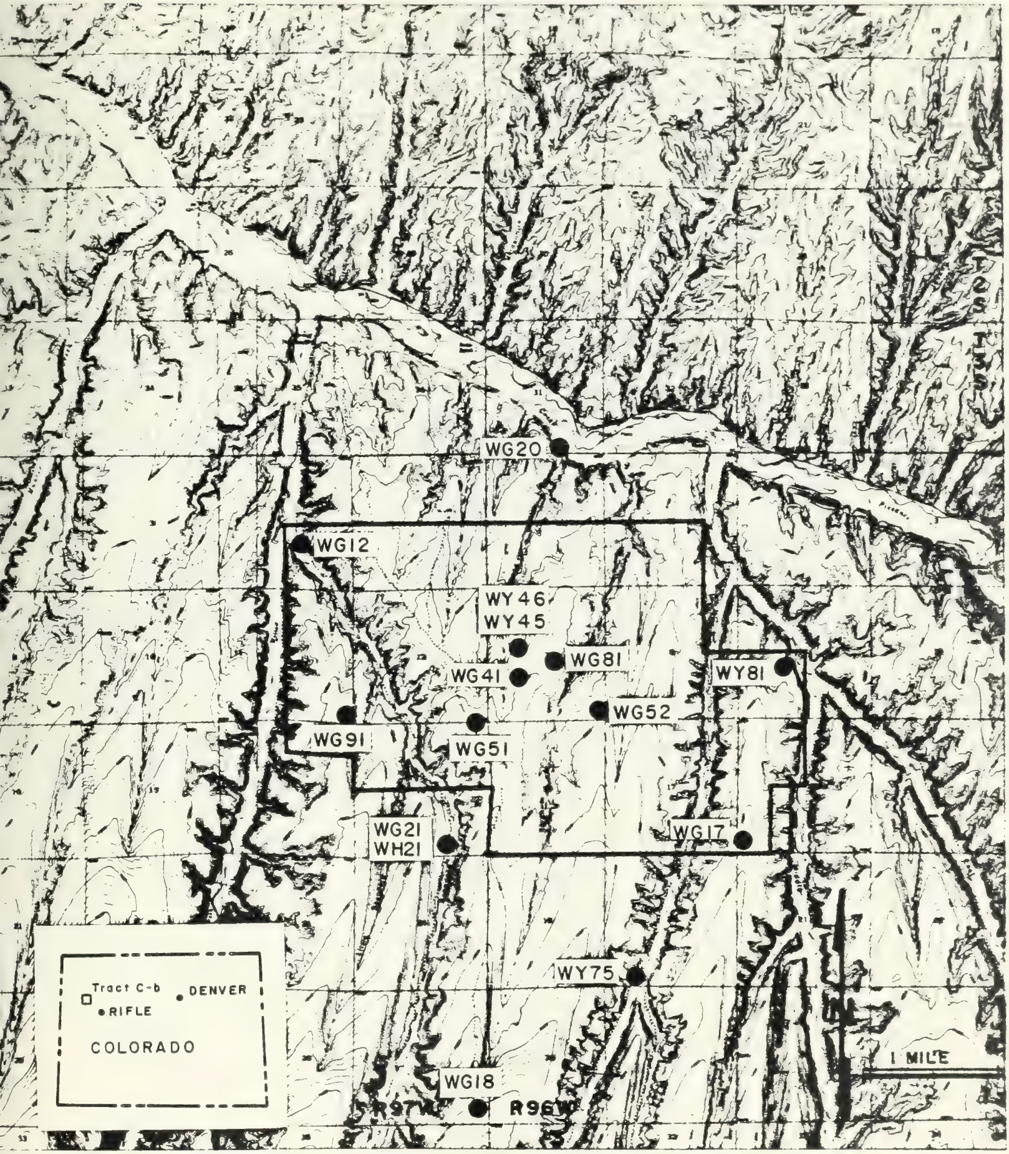


Figure 8.5-10 DEEP WELL MONITORING NETWORK NEAR C-b TRACT FOR LPC_3, LPC_4 ZONES

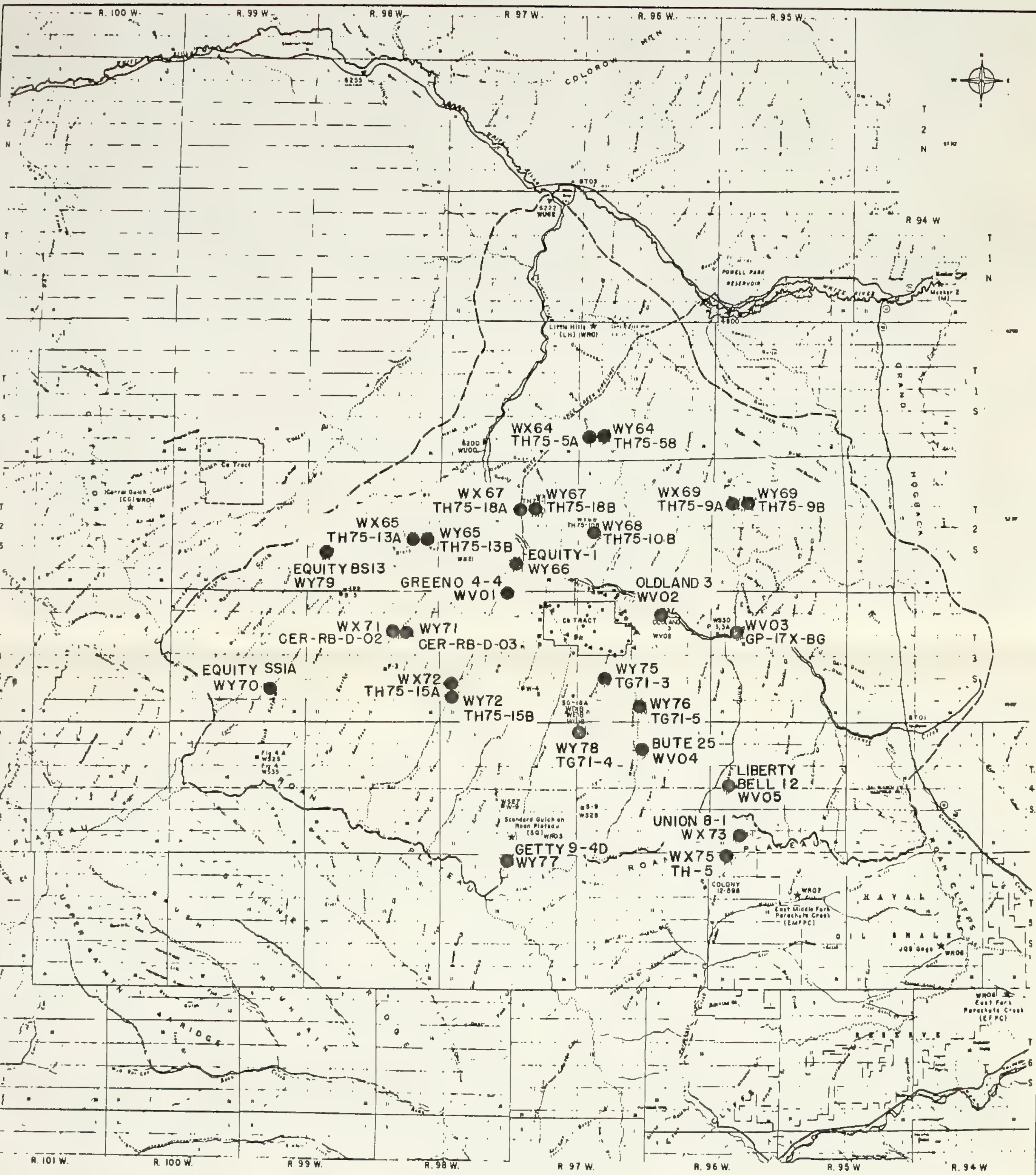


Fig. 8.5-11 ADDITIONAL BEDROCK WELLS MONITORED UNDER WATER AUGMENTATION PLAN

TABLE 8.5-4
Bedrock Wells Status and Sampling Schedule

Computer Code	Designation	Owner of Well	Formation	Frequency: Levels C & P	Frequency: Water Quality C	Frequency: Water Quality P	Measured By
WE03	CB-3	CB	UPC2	M	-		A
WE04	CB-4	CB	UPC2	M	-		A
WG1	SG-1-1	CB	LPC3	C	S_1	S	A
WD12	SG-1-2	CB	UPC1	C	S_1	S	A
WE11	SG-1A-1	CB	UPC2	S	-		A
WD11	SG-1A-2	CB	UPC1	S	-		A
WE61	SG-6-1	CB	UPC2	M	-		A
WG61	SG-6-2	CB	LPC3	M	-		A
WD61	SG-6-3	CB	UPC1	M	-		A
WY81	SG-8R	CB	Lower Aquifer	M	S_1	S	A
WG91	SG-9-1	CB	LPC3	B	-		A
WE91	SG-9-2	CB	UPC2	B	-		A
WD91	SG-9-3	CB	UPC1	B	-		A
WC91	SG-9-4	CB	Uinta	B	-		A
WG51	SG-10A-1	CB	LPC3	M	-		A
WE51	SG-10A-2	CB	UPC2	M	-		A
WD51	SG-10A-A	CB	UPC1/CON. UINTA	M	-		A
WD90	SG-10	CB	UN. UINTA	C	Q_1	S	A
WG52	SG-11-1	CB	LPC3	M	-		A
WE52	SG-11-2	CB	UPC2	M	-		A
WD52	SG-11-3	CB	UPC1	M	-		A
WG17	SG-17-1	CB	LPC3	B	-		A
WE17	SG-17-2	CB	UPC2	B	-		A
WD17	SG-17-3	CB	UPC1	B	-		A
WC17	SG-17-4	CB	Uinta	B	-		A
WD57	SG-17A	CB	UPC1	B	S_1	S	A
WG18	SG-18A-1	CB	LPC3	Q	-		A
WE18	SG-18A-2	CB	UPC2	Q	-		A
WD18	SG-18A-3	CB	UPC1	Q	-		A
WD19	SG-19	CB	UPC1	M	-		A
WG20	SG-20-1	TOSCO	LPC3	CAPPED	-		A
WE20	SG-20-2	TOSCO	UPC2	M	S_1	S	A
WD20	SG-20-3	TOSCO	UPC1	M	S_1	S	A
WH21	SG-21-1	CB	LPC4	M	-		A
WG21	SG-21-2	CB	LPC3	M	-		A
WE21	SG-21-3	CB	UPC2	M	-		A
WD21	SG-21-4	CB	UPC1	M	-		A
WV37	AT-1A	CB	COMPOSITE	M	-		A
WX38	AT-1A-1	CB	UPPER AQUIFER	M	-		A
WY45	AT-1C-1	CB	LOWER AQUIFER	W	Q	S	A
WY46	AT-1C-2	CB	LOWER AQUIFER	W	-		A
WX44	AT-1C-3	CB	UPPER AQUIFER	C	Q	S	A
WG41	AT-1D-1	CB	LPC3	B	-		A
WE41	AT-1D-2	CB	UPC2	B	-		A
WD41	AT-1D-3	CB	UPC1	B	-		A
WD14	14X-7-1	CB	UPC1	M	-		A
WD15	14X-7-2	CB	UPC1	B	-		A
WV07	21X-12	CB	COMPOSITE	S	-		A
WV08	22X-1	CB	COMPOSITE	S	-		A
W119	22X-17	CB	UPC2 & LPC3	M	-		A
W117	24X-17	CB	UPC2 & LPC3	M	-		A

TABLE 8.5-4 (Cont'd)
Bedrock Wells Status and Sampling Schedule

Computer Code	Designation	Owner of Well	Formation	Frequency: Levels C & P	Frequency: Water Quality C	Frequency: Water Quality P	Measured By
WW22	31X-12	CB	UN. UINTA	W	M_1/S	S	A
WX32	32X-12	CB	UPC2	C	S_1	S	A
WW32	32Y-12	CB	UN. UINTA	M	Q_1	S	A
WW13	41X-13	CB	UN. UINTA	W	M_1/S	S	A
WV09	43X-2	CB	COMPOSITE	S	-		A
WV10	TG-71-1	CB	COMPOSITE	Q	-		A
WX75	TH-5**	US	UPPER AQUIFER	Q	-		A
WX54	TH75-5A	US	UPPER AQUIFER	Q	-		A
WY64	TH75-5B	US	LOWER AQUIFER	Q	-		A
WX69	TH75-9A	US	UPPER AQUIFER	Q	-		A
WY69	TH75-9B	US	LOWER AQUIFER	Q	-		A
WY68	TH75-10B	US	LOWER AQUIFER	Q	-		A
WX65	TH75-13A	US	UPPER AQUIFER	Q	-		A
WY65	TH75-13B	US	LOWER AQUIFER	Q	-		A
WX67	TH75-18A	US	UPPER AQUIFER	Q	-		A
WY67	TH75-18B	US	LOWER AQUIFER	Q	-		A
WX72	TH75-15A	US	UPPER AQUIFER	Q	-		A
WY72	TH75-15B	US	LOWER AQUIFER	Q	-		A
WY66	EQUITY 1	EQUITY	LOWER AQUIFER	Q	-		A
WY70	EQUITY S1A	EQUITY	LOWER AQUIFER	Q	-		A
WV01	GREENO-404	SHELL	COMPOSITE	Q	-		A
WX71	CER RB-D-02	US	UPPER AQUIFER	Q	-		A
WY71	CER RB-D-03	US	LOWER AQUIFER	Q	-		A
WY75	TG-71-3	TOSCO	LOWER AQUIFER	Q	-		A
WY78	TG-71-4	TOSCO	LOWER AQUIFER	Q	-		A
WY76	TG-71-5	TOSCO	LOWER AQUIFER	Q	-		A
WV02	OLDLAND 3	TOSCO	COMPOSITE	Q	-		A
WV03	GP-17X-BG	US	COMPOSITE	Q	-		A
WV04	BUTE 25	TOSCO	COMPOSITE	Q	-		A
WV05	LIBERTY BELL 12	TOSCO	COMPOSITE	Q	-		A
WX73	UNION 8-1	UNION	UPPER AQUIFER	Q	-		A
WY77	GETTY 9-4D	GETTY	LOWER AQUIFER	Q	-		A
WY79	EQUITY BS-13	EQUITY	LOWER AQUIFER	Q	-		A

**Colony TH-5 replaced Colony 12-596

B = Bimonthly
M = Monthly
S = Semiannual
S/F = Semiannual Field Measurements
C = Continuous
Q = Quarterly
A = Applicant
N/D = Monthly, if not Diverted
M_1 = Monthly for Field Measurements + Fluoride
Q_1 = Quarterly for Field Measurements + Fluoride
S_1 = Semiannual but may be Changed Pending Evaluation of Hydrographs
C = Current Interim Monitoring Program
P = Proposed for Development Monitoring

UN. = Unconsolidated
CON. = Consolidated

8.5.2.4.1.1 Near/On-Tract Wells

During and subsequent to the 1981 water year, the understanding of the geohydrology of the C-b Tract was advanced further than in any previous time period. A major contributing factor to the advancement of knowledge was the analysis of data obtained during the reinjection experiment that occurred from March 2 through June 20, 1981. Levels in the bedrock monitoring wells on and near the C-b Tract were significantly affected, and levels in these wells provided data for the interpretation of the reinjection experiment results.

Water levels have been measured on and off the C-b Tract for many years prior to reinjection. This activity provided a general understanding of the potentiometric water levels within the bedrock. In order to improve this understanding and to relate the observations more closely to the four aquifer model, a program was developed to recomplete many of the wells. Recompletions were done before beginning the reinjection test by recementing and reperforating existing strings or by installing, cementing, and perforating new strings. The number of completions per well ranged from one to as many as five including the annular space. The recompletion program was finished a few months before the start of reinjection. Detailed diagrams of the recompleted wells were provided to the OSPO in Development Monitoring Report #6, dated July 15, 1981.

Well monitoring data have been used to develop contour maps. These maps provide a baseline that can be compared with the reinjection test results. Long-term piezometric surfaces prior to reinjection showed an overall slope to the north. Another long-term configuration, also unrelated to CB activities, is a trough in the piezometric surface extending and sloping to the northwest.

8.5.2.4.1.2 Remote/Off-Tract Wells

Starting in the summer of 1979, monitoring of additional remote off-Tract bedrock wells was required under the Water Augmentation Plan. These wells include all remote wells monitoring water in the bedrock except for two wells near the northern Tract boundary (SG-19 and SG-20), and two wells south of the Tract (SG-18 and SG-21). SG-18 is almost two miles south of the Tract, but it is monitored with and at the same frequency as the on-Tract wells. All the wells referred to are completed as either Upper Aquifer Wells (WX), Lower Aquifer Wells (WY), or are composite wells open to both intervals (WV), as in the older USGS system.

North of Piceance Creek, three of these remote wells monitor the Upper Aquifer (WX64, WX67 and WX69) and four wells monitor the Lower Aquifer (WY64, WY67, WY68, and WY69). East of the C-b Tract, the two monitoring wells (WV02 and WV03) are open to both Upper and Lower Aquifers. Southeast and south of the Tract, WX73 and WX75 monitor the Upper Aquifer; WY75, WY76 and WY77 monitor the Lower Aquifer; and WV-4 and WV05 are open to both. Three of these wells (WY76, WY77 and WV05) were flowing during the 1981 water year. Southwest and west of the Tract, WX71 and WX72 monitor the Upper Aquifer, and the Lower Aquifer is monitored by WY70, WY71 and WY72. West and northwest of the Tract, WX65 monitors the Upper Aquifer; WY65, WY66 and WY79 monitor the Lower Aquifer and WV01 is open to both aquifers. WY66 was flowing during the 1981 water year.

The objectives for monitoring the wells on and near the C-b Tract are to gather data to use in the determination of the magnitude and the vertical and horizontal extent of effects that dewatering and reinjection activities may have on the groundwater regime.

8.5 Hydrology and Water Quality

The basic objective in monitoring remote off-Tract bedrock wells is to obtain data for the interpretation of the subsurface geohydrology and to determine the distance and magnitude of the influence that shaft dewatering and reinjection activities may have on the (Upper and Lower) aquifer system.

8.5.2.4.3 Experimental Design

Sampling frequency for levels varies from continious to semi-annual depending on the well, as indicated on Table 8.5-4. The sampling frequency used during Interim Monitoring is advocated to be continued during Development Monitoring.

Data are analyzed by the application of a linear regression model to determine the existence of both short- or long-term time trends in the water levels, as appropriate. (The reinjection test and program caused non-linearities making such analyses inappropriate for periods of time.) In addition, time series plots are prepared for qualitative analysis and comparisons.

8.5.2.5 Mine Water Management

8.5.2.5.1 Introduction and Scope

Various alternatives to management of excess water produced on-Tract that have been implemented include storage in temporary impoundments, discharge, reinjection or land application through the sprinkler irrigation system. Figure 8.5-12 presents the water management system layout. Figure 8.5-13 is a diagram of holding Ponds A and B, and Figure 8.5-14 shows Pond C. As previously mentioned in Sections 6.3 and 6.4, discharge from Pond A and B is the current and proposed method.

When water is discharged, flow is monitored at the Pond A/B discharge point and at surface water gauging station WU42 in East No Name Gulch near its confluence with Piceance Creek. Monitoring the discharge point is required under

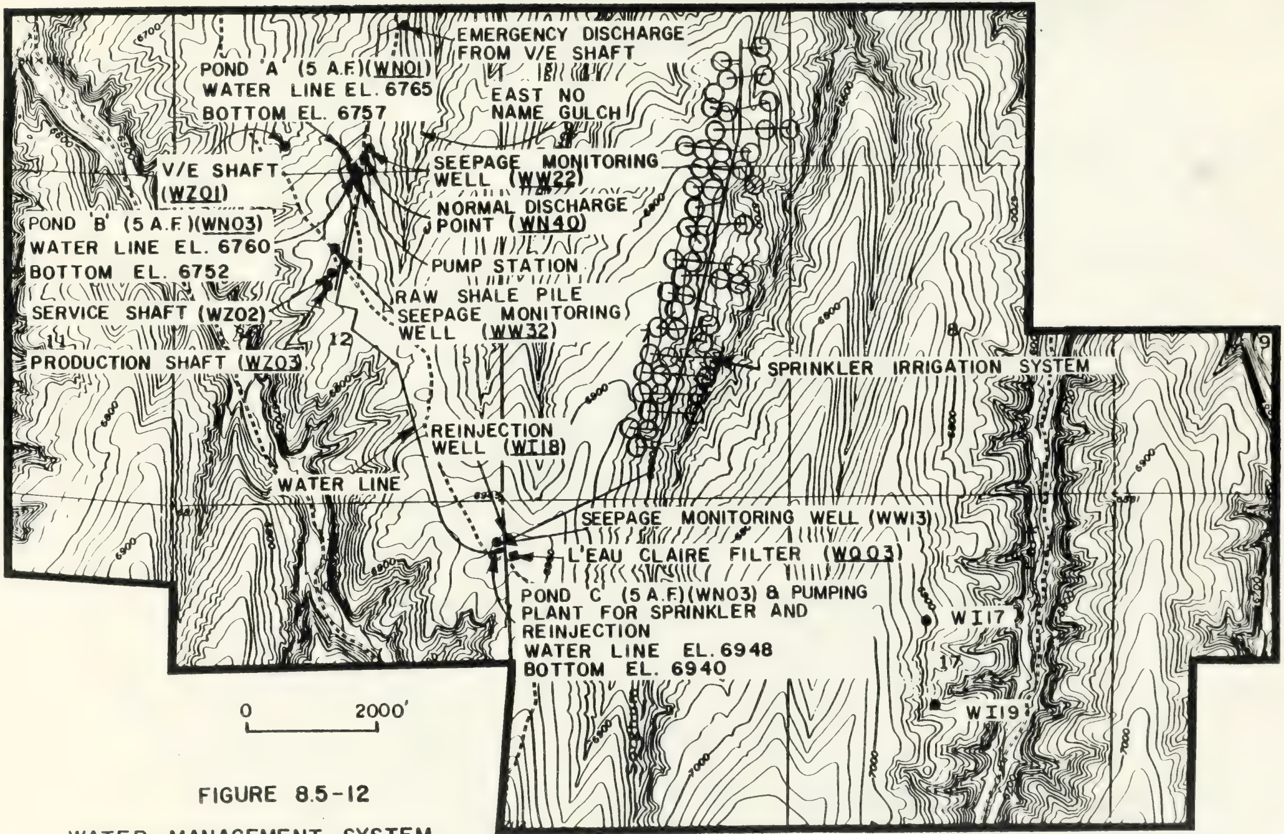


FIGURE 8.5-12

WATER MANAGEMENT SYSTEM
LAYOUT

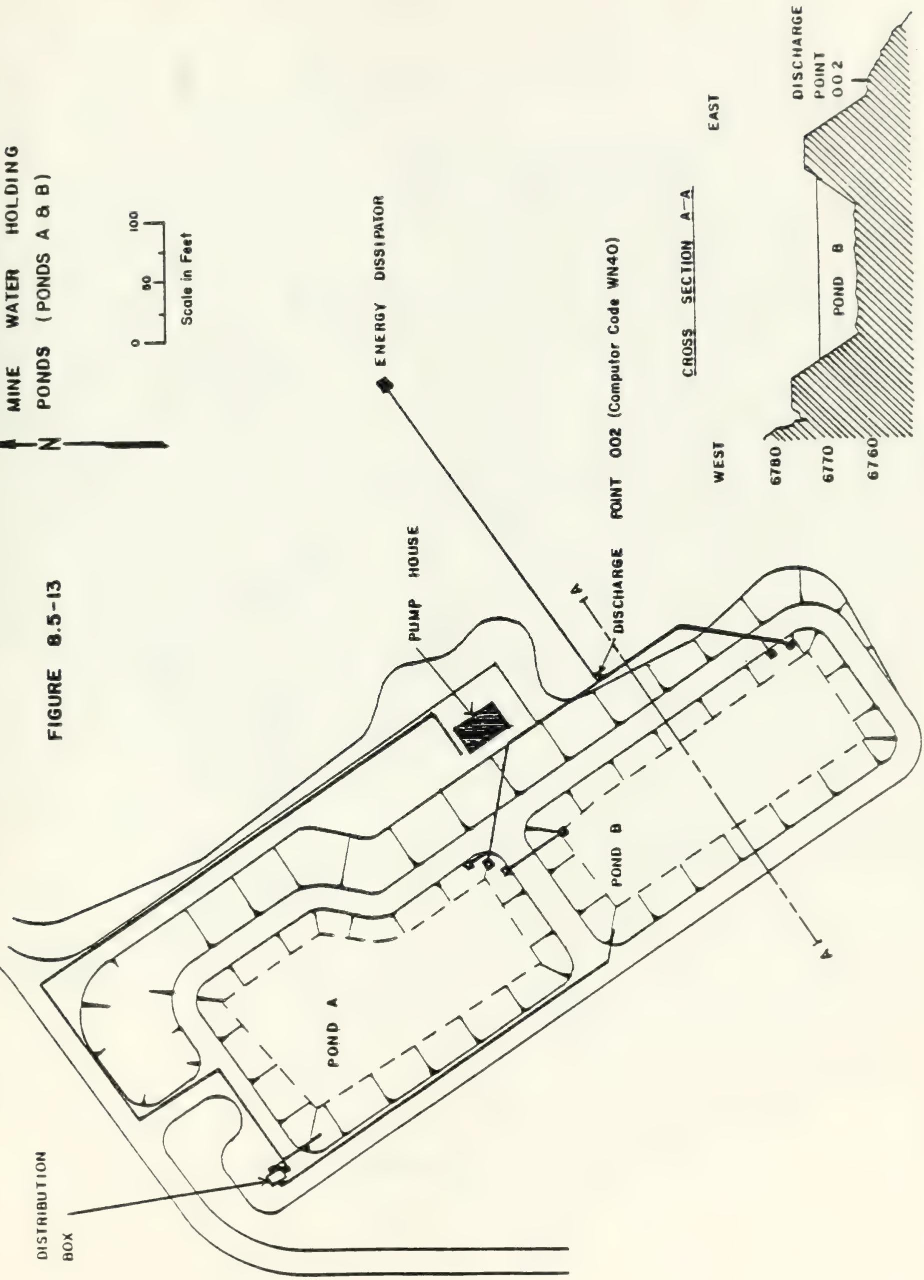
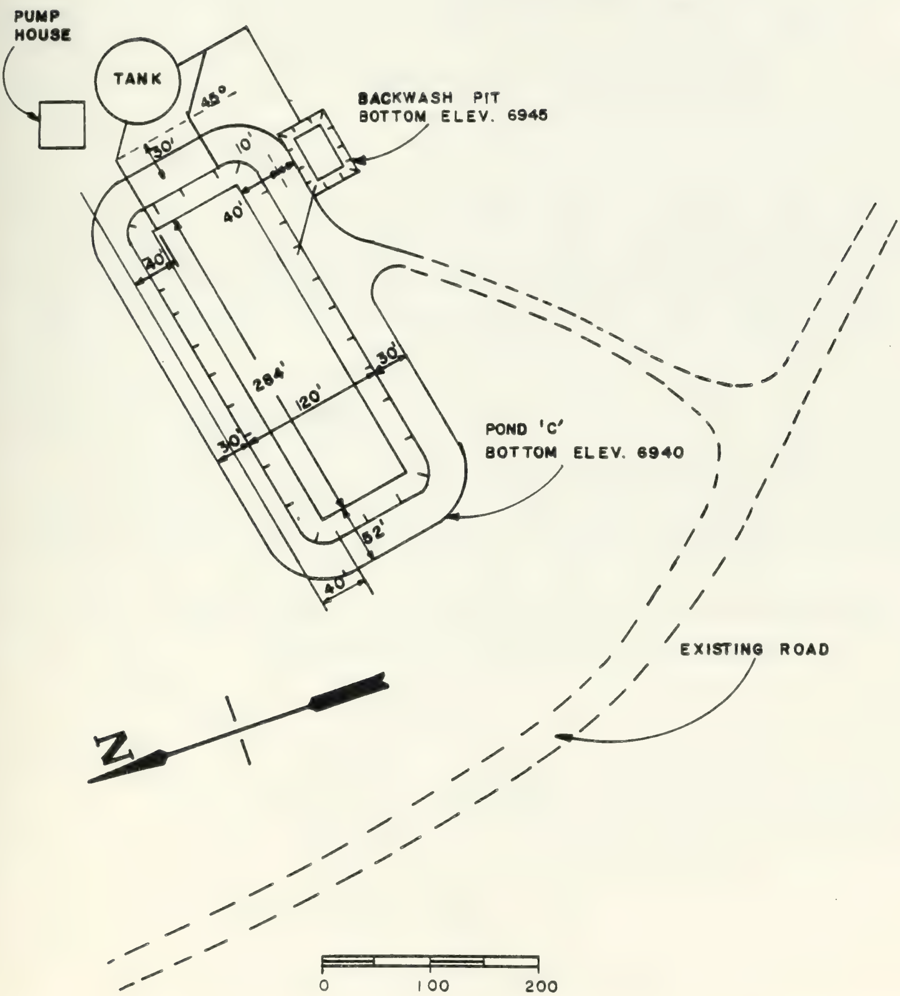


FIGURE 8.5-13

LOWER 5 ACRE-FOOT MINE WATER HOLDING PONDS (PONDS A & B)

FIGURE 8.5-14

UPPER 5 ACRE MINE WATER HOLDING POND (POND 'C')



the NPDES discharge permit for water quality parameters; see Section 8.5.3.5. A monthly summary of the water make from the shafts, water used, and water discharged is required to be submitted to the State Engineer under the Water Augmentation Plan; a typical table, previously cited, is Table 6.3-3.

8.5.2.5.2 Objectives

The objective in water management with regard to monitoring of water quantity is to measure water discharge water from the shafts, nearby surface stream and spring flows and to monitor water levels in various key wells. Treatment of water quality for the present water management system is discussed in detail in Section 8.5.3.5.

8.5.2.5.3 Experimental Design

Instantaneous flow measurements of the discharge from Ponds A and B are converted to daily averages, daily maximum for the month and monthly total. The following data are obtained and reported monthly to the State Engineer and EPA.

Water pumped: from wells 33X1, 24X-25, 33X12, V/E shaft and the combined pumpage from the Production and Service Shafts.

Water in Storage: in Ponds A, B, C

Tract water used: for batch plant, constructon, dust control, evaporation and leakage, NPDES discharge, reinjection, sprinkler and irrigation.

Off-Tract Water Used: Potable water

Gland-Seal Water Used: Water used to operate pumps

Monthly and yearly cumulative values of all parameters are obtained.

8.5 Hydrology and Water Quality

The water management plan also monitors water levels at reinjection well locations, seepage monitoring wells and in the V/E shaft.

The reinjection well locations (Figure 8.5-12) are WI17, WI18, and WI19, noting that up to the present only WI18 has been utilized for reinjection; historical operational (sampling) timelines for levels are presented in the CB data reports.

Seepage monitoring well WW12 (later recompleted to WW22) monitors seepage, if any, from Ponds A and B and WW 13 monitors the seepage from Pond C. Well WW32 monitors seepage, if any, from the raw shale pile. Historical operational (sampling) timelines for levels are shown in the data reports.

On September 1, 1981, dewatering of the V/E shaft was terminated and it was allowed to fill (with OSPO approval). This was a cost control measure that greatly reduced dewatering pumping requirements. Water level in the V/E shaft is monitored as station WZ01; historical operational (sampling) timelines for levels are shown in the CB data reports. Dewatering the V/E shaft will resume in accord with the schedule for mining in that area.

8.5.2.6 Data Comparisons Required by the Water Augmentation Plan

8.5.2.6.1 Introduction and Scope

Specific comparisons of selected data are required by the Water Augmentation Plan including: the comparison between Piceance Creek flow and precipitation at various flow measurement stations, comparison between precipitation measurements in the Tract area and measurements at the Little Hills station, and comparison between flows from selected springs and water levels in a selected bedrock well.

In general, flow measurements and precipitation measurements taken at distant stations historically have been uncorrelated. The lack of correlation demonstrates that precipitation is subject to marked spatial variability, especially in rough terrain. Analyses for lagged correlation between streamflow and precipitation did not improve the lack of correlation due to variability. Correlation was shown between measurements at precipitation stations and stream gauges that were nearby, as would be expected.

Comparison between data from selected springs and the bedrock well showed no correlation whatsoever. The level in this well decreases monotonically through the period from October 1979 to October 1980, whereas the flows from the springs exhibited nonuniform increases and decreases during the same period.

8.5.2.6.2 Objectives

The objectives in performing the required data comparisons were to investigate the correlation between precipitation and streamflow from several different measurement locations, and to compare flows from selected springs with the level in an alluvial well.

8.5.2.6.3 Experimental Design

The required data comparisons will be repeated even though results are not expected to differ significantly from results obtained previously.

8.5.2.7 Hydrogeologic Mapping of C-b Shafts

8.5.2.7.1 Introduction and Scope

Mapping of the hydrogeology of the three main shafts was done to provide better understanding of the groundwater hydrology and subsurface geology.

8.0 DEVELOPMENT MONITORING PROGRAM

8.5 Hydrology and Water Quality

Examinations of the detailed structure within the Parachute Creek Formation have been obtained. This phase to shaft terminal depths is now completed . Information is used in water management and mine planning. No further work in this area is planned.

8.5.3 Water Quality

8.5.3.1 Streams

8.5.3.1.1 Introduction and Scope

The spatial limits of the stream quality monitoring program are from the USGS station WU07 upstream from the C-b Tract to USGS WU62 downstream and west of the Tract at the White River. The locations of these stations and other USGS stations were shown previously on Figures 8.5-1 and -2 and described in Table 8.5-1. The program includes stations on streams tributary to Piceance Creek that are on or adjacent to the Tract as well as on Piceance Creek itself. The sampling frequency and parameters measured at USGS stations are shown in Table 8.5-5. USGS sampling methods are shown on the same table. The Water Augmentation Plan also requires measurements of water quality at USGS stations for the same parameter list.

8.5.3.1.2 Objectives

The objectives of the monitoring program for surface stream water quality are to establish background information on the range and variability of water quality parameters in surface streams, to detect significant changes in water quality, and to attempt to identify causes for changes that may be identified. It is to be noted with respect to the third objective that range and variability in water quality parameters are produced not only by natural causes, but also by activities of man, such as agricultural and livestock activities in connection with local ranching, oil and gas production involving many deep wells and other activities.

TABLE 8.5-5

Parameters Analyzed during Interim Monitoring and Proposed for Development Monitoring Phase for USGS Gauging Stations

Continuous Data	USGS Method Number
Flow (cfs)	--
Temperature (°C)	--
Specific Conductance (umhos)	I-2781-81
pH	I-2587-79
DO (mg/l)	--
Suspended Sediments	--
Data Collected Bi-Monthly	
Alkalinity (mg/l as $CaCO_3$)	I-2030-78
Ammonia (mg/l as N)	I-4523-78
Boron (ug/l as B)	I-1110-78
Calcium (mg/l as Ca)	I-1152-78
Fluoride (mg/l as F)	I-2327-78
Iron (ug/l as Fe)	I-1381-78
Magnesium (mg/l as Mg)	I-1447-78
Potassium (mg/l as K)	I-1630-78
Silica (mg/l as SiO_2)	I-2700-78
Sodium (mg/l as Na)	I-1735-78
Bicarbonate (mg/l as $CaCO_3$)	Calculation
Carbonate (mg/l as $CaCO_3$)	Calculation
Chloride (mg/l as Cl)	I-2187-78
TDS (mg/l)	I-1749-78
Kjeldahl Nitrogen (mg/l as N)	I-2552-78
Nitrate and Nitrite (mg/l as N)	I-2545-78
Arsenic (ug/l as As)	I-2062-78
Manganese (ug/l as Mn)	I-1454-78
Phosphate (mg/l as P)	I-1601-78
DOC (mg/l as C)	0-ØØØ2-78
Suspended Organic Carbon (mg/l as C)	0-ØØØ3-78
Sulfate (mg/l as SO_4)	I-2822-78
Total Suspended Solids (mg/l)	I-3765-78
Phenols, Total (ug/l as Phenol)	EPA Code 420.1
Data to be Collected Semi-annually	
Aluminum (ug/l as N)	I-1052-78
Bromide (mg/l as Br)	I-1127-78
Barium (ug/l as Ba)	I-1084-78
Cadmium (ug/l as Cd)	I-1136-78
Copper (ug/l as Cu)	I-1271-78
Chromium (ug/l as Cr)	I-1236-78
Oil and Grease (mg/l)	0-1555-74
Lead (ug/l as Pb)	I-1400-78
Lithium (ug/l as Li)	I-1425-78

TABLE 8.5-5 (Cont'd)

Parameters Analyzed during Interim Monitoring and Proposed for Development Monitoring Phase for USGS Gauging Stations

Data Collected Semi-Annually

Mercury (ug/l as Hg)	I-2462-78
Molybdenum (ug/l as Mo)	I-1490-78
Selenium (ug/l as Se)	I-1667-78
Sulfide (mg/l as S)	I-3840-78
Zinc (ug/l as Zn)	I-1900-78
Cyanide (mg/l as Cn)	I-2302-78
Strontium (ug/l as Sr)	I-1800-78
*Fecal Coliform	Standard Method
*Fecal Streptococcus	Standard Method
*Total Coliform	Standard Method
COD (mg/l)	I-3561-78
*BOD	Standard Method
Gross Alpha (ug/l as U natural)	R-1120-76
Gross Beta (pci/l)	R-1120-76
DOC Fractionation	Leenheer & Huffman Method

*(WU07, WU42, WU61 only)

8.5.3.1.3 Experimental Design

Data from the monitoring network are collected and analyzed according to the schedules and parameters noted in Table 8.5-5. All water quality samples are analyzed by procedures previously used during the Environmental Baseline Study. Analysis and data verification for the USGS stations are performed by the USGS laboratories in Denver and by the USGS Subdivision office in Meeker. Linear regression analyses are used as an initial screening technique to test for the existence of linear trends with time at a five percent level of significance. Similarly most pertinent data will be plotted as time series for visual examination of trends and/or outliers.

8.5.3.2 Springs and Seeps

8.5.3.2.1 Scope and Introduction

A substantial contribution to the base flow in Piceance Creek comes from springs and seeps; thus springs water quality influences that of Piceance Creek. Water quality data have been gathered since the baseline phase; new springs were added by the requirements of the Water Augmentation Plan. Springs locations were shown previously as Figure 8.5-4 and 8.5-5 reflecting these requirements. Parameters and sampling frequency for water quality of springs are shown in Table 8.5-6, and historical sampling timelines are given in the CB data reports.

8.5.3.2.2 Objectives

Objectives in monitoring the water quality of springs are to establish the natural variability, (in springs water quality), to provide data for the investigation of the sources of springs, and to obtain information that may be used in defining the potential relationship with alluvial waters, and groundwater.

TABLE 8.5-6

Parameters Proposed for Development Monitoring Phase for Springs

Parameter	Frequency	EPA Analytical Code
Flow (cfs)	Monthly	--
pH	Monthly	150.1
Temperature (°C)	Monthly	--
Specific Conductance (umhos)	Monthly	--
Ag (mg/l)	Quarterly	272.1
As (mg/l)	Quarterly	206.4
Ba (mg/l)	Quarterly	208.1
Cd (mg/l)	Quarterly	213.1
Cr (mg/l)	Quarterly	218.1
Cu (mg/l)	Quarterly	220.1
Fe (mg/l)	Quarterly	236.1
Hg (mg/l)	Quarterly	245.1
Mn (mg/l)	Quarterly	243.1
Pb (mg/l)	Quarterly	239.1
Mo (mg/l)	Quarterly	246.2
Cl (mg/l)	Quarterly	325.3
Li (mg/l)	Quarterly	--
Al (mg/l)	Quarterly	202.1
Sr (mg/l)	Quarterly	USGS Method I-1800-78
Se (mg/l)	Quarterly	270.2
Zn (mg/l)	Quarterly	289.1
Na (mg/l)	Quarterly	273.1
K (mg/l)	Quarterly	258.1
Ca (mg/l)	Quarterly	215.1
Mg (mg/l)	Quarterly	242.1
F (mg/l)	Quarterly	340.2
B (mg/l)	Quarterly	212.3
Ni (mg/l)	Quarterly	249.2
Oil & Grease (mg/l)	Quarterly	413.1
Kjeldahl-N (mg/l)	Quarterly	351.3
COD (mg/l)	Quarterly	410.1
BOD (mg/l)	Quarterly	405.1
TDS (mg/l)	Quarterly	160.1
SO_4 (mg/l)	Quarterly	375.4
CO_3 (mg/l as $CaCO_3$)	Quarterly	Calculation
HCO_3 (mg/l as $CaCO_3$)	Quarterly	Calculation
NO_3 (mg/l)	Quarterly	352.1
Alkalinity (mg/l)	Quarterly	310.1
Hardness (mg/l)	Quarterly	413.1
Phenols (mg/l)	Quarterly	420.1
Ammonia (mg/l)	Quarterly	350.2
DOC Fraction (mg/l)	Semi-annually	Leenheer & Huffman Method
Fecal Coliform (mg/l)	Semi-annually	--
Total Coliform (mg/l)	Semi-annually	--
Br (mg/l)	Annually	320.1
Fecal Streptococcus (mg/l)	Semi-annually	--
Gross Alpha (pci/l)	Semi-annually	USGS Method R-1120-76
Ra226 (pci/l)	Semi-annually	USGS Method R-1120-76
Gross Beta (pci/l)	Semi-annually	USGS Method R-1120-76

8.5.3.2.3 Experimental Design

Water quality data from springs obtained according to the parameters and sampling frequency shown in Table 8.5-1 are analyzed for trends by linear regression analysis, visual examination of time series plots and use of tri-linear diagrams. The latter technique is useful for defining the hydrologic relationships among springs, alluvial waters, and groundwater.

8.5.3.3 Alluvial Wells

8.5.3.3.1 Introduction and Scope

Alluvial wells were drilled in all gulches at the C-b Tract and in the major drainages of Piceance Creek, Willow Creek, and Stewart Gulch. These wells were sampled over the two-year baseline period and are used for monitoring during development of C-b Tract. In addition to the 13 alluvial wells monitored during baseline, additional wells (WA55, WA56 and recently WA21, and WA22) were drilled and added to the monitoring network. The location of these wells were shown previously in Figure 8.5-7. The parameters and frequency of water quality sampling are shown in Table 8.5-7 and 8.5-3 respectively. The historical operational timelines for alluvial wells are presented in the CB data reports; sampling was discontinued in interim monitoring. Seepage monitoring wells are discussed in 8.5.3.6.

8.5.3.3.2 Objectives

The objectives of monitoring the water quality in the alluvium are to establish the natural variability, to obtain data for the investigation of the relationships among alluvial waters, surface waters, and bedrock waters. It is noteworthy to point out that the alluvium is subject to the same non-mining impacts that affect streams.

TABLE 8.5-7

Parameters Analyzed during Interim Monitoring and Proposed for Development Monitoring for Wells

Parameter	EPA Analytical Code
Levels (elevations)	--
pH	150.1
Temperature (°C)	--
Specific Conductance (umhos)	--
As (mg/l)	206.4
Mo (mg/l)	246.2
Cr (mg/l)	218.1
Cu (mg/l)	220.1
Fe (mg/l)	236.1
Hg (mg/l)	245.1
Mn (mg/l)	243.1
Radiology (pci/l)	USGS Method R-1120-76
Na (mg/l)	273.1
Br (mg/l)	320.1
Pb (mg/l)	239.1
Ca (mg/l)	215.1
Cl (mg/l)	325.3
Li (mg/l)	--
Al (mg/l)	202.1
Sr (mg/l)	USGS Method I-1800-78
Se (mg/l)	270.2
Zn (mg/l)	289.1
COD (mg/l)	410.1
Alkalinity (mg/l)	310.1
K (mg/l)	258.1
HCO_3 (mg/l as $CaCO_3$)	Calculation
Mg (mg/l)	242.1
F (mg/l)	340.2
B (mg/l)	212.3
Phenols (mg/l)	420.1
Ammonia (mg/l)	350.2
Hardness (mg/l)	413.1
NO_3 (mg/l)	352.1
Ba (mg/l)	208.1
CO_3 (mg/l as $CaCO_3$)	Calculation
SO_4 (mg/l)	375.4
TDS (mg/l)	160.1
Oil & Grease (mg/l)	413.1
*SiO_2 (mg/l)	370.1
*Cn (mg/l)	USGS Method I-2302-78
*Total phosphate (mg/l)	USGS Method I-2601-78

Additional Parameters Analyzed during Development Monitoring Phase

Parameter	EPA Analytical Code
Ag (mg/l)	272.1
BOD (mg/l)	405.1
Ni (mg/l)	249.1
Kjeldahl-Nitrogen (mg/l as N)	351.3
DOC (mg/l)	Leenheer & Huffman Method

* Parameters added during Interim Period which are not required during Development Monitoring.

8.5.3.3.3 Experimental Design

The parameters listed in Table 8.5-7 will be sampled in Development Monitoring according to the frequency indicated in Table 8.5-3. The data will be tested for trends in water quality with time by linear regression analysis. Time series plots of selected parameters will also be utilized. Tri-linear diagrams will be investigated as a potential method for defining the hydrologic relationships among alluvial waters, surface waters, and bedrock waters.

8.5.3.4 Bedrock Wells

8.5.3.4.1 Introduction and Scope

The wells used for monitoring the water quality of the bedrock are selected from those on and near-Tract used to monitor water levels; i.e., water quality monitoring is not required for the Water Augmentation Plan wells. The locations of bedrock wells are shown on Figures 8.5-9 and 8.5-10. Table 8.5-7 shows the specific wells, associated parameters and sampling frequency proposed for Development Monitoring in bedrock wells. Operational (sampling) timelines are shown in the CB data reports.

Several Upper Aquifer wells were recompleted during 1980 as discussed in Section 8.5.1.

Cross reference should also be made to Figure 6.4-1 which shows locations of bedrock wells superimposed on the mine layout plan. New monitoring wells planned for 1984 are also shown on this figure; they will be added to the network of this section (8.5) after they have been completed as monitoring wells.

8.5 Hydrology and Water Quality

The reader should refer back to Section 8.5.1.2 for the suggested list of parameters of most interest for monitoring water quality in the neighborhood of spent MIS retorts; a monitoring plan to accomodate such retorts will evolve as these retorts come on line.

8.5.3.4.2 Objectives

The objectives in monitoring the water quality of the bedrock aquifers are to obtain data to be used in the investigation of the hydrologic relationships among alluvial waters, surface waters, and the deep bedrock aquifers; to establish the range of water quality parameters in the bedrock aquifers; to monitor changes or trends in these parameters; and, if changes occur, determine if these are attibutable to Tract development.

8.5.3.4.3 Experimental Design

Variables of Table 8.5-7 are obtained and analyzed according to the schedule of Table 8.5-4. Selected data are plotted as time series and tested for time trends by linear regression analysis at the five percent level of significance. Tri-linear diagrams and other analytical listings will be investigated for potential use in analysis; one example of such use after the reinjection test in 1981 is shown on Figure 8.5-15. Alluvial/bedrock pairs will continue to be examined to determine whether communication between these aquifers occurs.

8.5.3.5 Mine Water Management

8.5.3.5.1 Introduction and Scope

Temporary storages designated as Ponds A, B, and C are used for water from the mine during development. The impoundment, land application, reinjection and discharge system has been summarized in other Sections. The locations of the water management system elements were shown in Figure 8.5-12. Water quality samples are obtained in the ponds, the Pond A and B discharge point (under the NPDES permit), the pond seepage monitoring wells, the shafts, and Piceance Creek

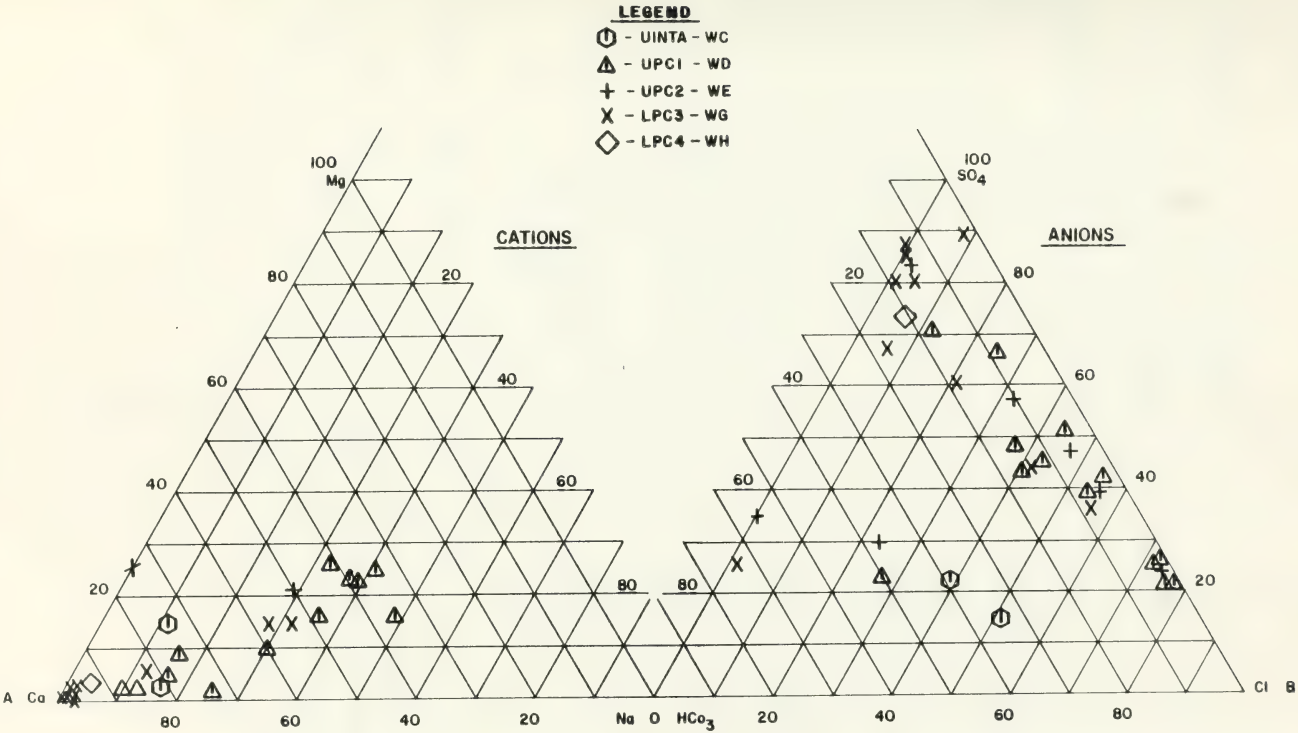


FIGURE 8.5-15 MULTIPLE-TRILINEAR DIAGRAMS OF SELECTED WATER QUALITY CONSTITUENTS FOR C-b BEDROCK WELLS FOR ONE SAMPLE TAKEN AFTER THE REINJECTION TEST IN 1981.

and its tributaries. These stations are as follows:

Location	Stations (Figure 8.5-12)
Pond A	WN01
Pond B	WN03
Ponds A/B Discharge	WN40
Reinjection Well	WI18
Wells Drilled for Potential Future Reinjection Sites	WI17, WI19
Seepage Monitoring Wells	
Ponds A/B	WW22
Pond C	WW13
Shafts	
Production Shaft	WZ03
Service Shaft	WZ02
V/E Shaft	WZ01

8.5.3.5.2 Objectives

Water quality is sampled at the Pond A/B discharge (WN40) to ensure compliance with the effluent limitations contained in the NPDES permit. The objective in sampling wells WW22 and WW13 is to detect changes that may determine the potential effects of seepage from Ponds A, B, and C on the water quality of the Uinta aquifer: Water quality samples have been historically drawn from the shafts as functions of depth during shaft sinking; periodic samples are obtained from the flooded V/E shaft.

8.0 DEVELOPMENT MONITORING PROGRAM

8.5 Hydrology and Water Quality

8.5.3.5.3 Experimental Design

8.5.3.5.3.1 NPDES Compliance

The revised National Pollution Discharge Elimination System (NPDES) permit was issued on August 31, 1983. The terms of the permit require weekly monitoring of the mine water discharge from the Tract at Station 002 (WN40). The parameters to be monitored are listed in Table 8.5-8.

Semi-annual samples were taken during 1979-1982 requiring additional parameters to be analyzed. This requirement has been changed in the revised NPDES permit No. CO-0033961 to a one-time sample, with results submitted no later than 90 days after the effective date of the permit. Parameters to be analyzed and associated EPA analytical method code are shown in Table 8.5-9. Previous semi-annual samples contained analysis of parameters not presented in Table 8.5-9; these are shown in Table 8.5-10.

8.5.3.5.3.2 Lease Compliance

The parameters sampled in the seepage monitoring wells along with typical results are shown in Table 8.5-11. Historical monitoring frequency is indicated on the operational timelines in the CB data reports; prior to Interim Monitoring sampling was monthly; reversion to monthly sampling for Development Monitoring is proposed. Data are analyzed for time trends by linear regression analysis. The use of tri-linear diagrams and other analytical techniques will be studied for analyzing data from the seepage monitoring wells and the ponds.

Regarding injection wells and shafts the parameter list is similar to that for the seepage wells; historical operational timelines are shown in the CB data reports, indicating irregular sampling intervals. Parameters previously sampled in the V/E shaft probe holes are listed in Table 8.5-12.

TABLE 8.5-8

Parameters Analyzed Under the Revised NPDES Permit and Associated Sampling Frequency

	Frequency	EPA Analytical Code
- Flow (cfs)	Daily	--
- NH_3 (mg/l)	Weekly	350.2
- Total Fe (mg/l)	Weekly	236.1
- Total dissolved solids (mg/l)	Weekly	160.1
- Total B (mg/l)	Weekly	212.3
- Total Ag (mg/l)	Weekly	272.2
- Total Hg (mg/l)	Weekly	245.1
- Total suspended solids (mg/l)	Weekly	160.2
- F (mg/l)	Weekly	340.2
- Total Cd (mg/l)	Weekly	213.2
- Total Cu (mg/l)	Weekly	219.2
- pH	Weekly	150.1
- Oil and Grease (mg/l)	Weekly	413.1
- Soluble Al (mg/l)	Weekly	202.1

TABLE 8.5-9

Parameters to be Analyzed for NPDES One-time Sample

Parameter	EPA Analytical Code
Temperature (°C)	--
Dissolved Oxygen (mg/l)	--
Total Alkalinity (mg/l)	310.1
pH	150.1
Total Suspended Solids (mg/l)	160.2
Fecal Coliform (#/100 ml)	--
Total Residual Chlorine (mg/l)	330.1
Ammonia (mg/l)	350.2
Fluoride, Total & Dissolved (mg/l)	340.2
Nitrate (mg/l)	352.1
Nitrite (mg/l)	354.1
Sulfide as H_2S (mg/l)	376.1
Boron, Total & Dissolved (mg/l)	212.3
Chloride (mg/l)	325.3
Sulfate (mg/l)	375.4
Aluminum, dissolved (mg/l)	202.1
Gross Alpha (pCi/l)	--
Radium 226 and 228	--
Copper, Total (mg/l)	220.1
Cyanide, Total (mg/l)	335.1
Iron, Total & Dissolved (mg/l)	236.1
Lead, Total (mg/l)	239.1
Molybdenum, Total (mg/l)	246.2
Mercury, Total (mg/l)	245.1
Nickel, Total (mg/l)	249.1
Phenols, Total (mg/l)	420.1
Selenium, Total (mg/l)	270.2
Silver, Total (mg/l)	272.1
Uranium, Total (mg/l)	--
Zinc, Total (mg/l)	289.1
Arsenic, Total (mg/l)	206.4
Cadmium, Total (mg/l)	213.1

TABLE 8.5-10

Additional Parameters Analyzed for Semi-Annual NPDES Samples

Parameter	EPA Analytical Code
Total Dissolved Solids (mg/l)	160.1
Oil and Grease (mg/l)	413.1
Total Barium (mg/l)	208.1
Calcium, Dissolved (mg/l)	215.1
Chromium, Total (mg/l)	218.1
Lithium, Total (mg/l)	--
Maganese, Total (mg/l)	243.1
Potassium, Total (mg/l)	258.1
Sodium, Total (mg/l)	273.1
Strontium, Total (mg/l)	USGS Standard Method Used
Titanium, Total (mg/l)	283.2
Vanadium, Total (mg/l)	286.2
COD (mg/l)	410.1
Kjeldahl Nitrogen (mg/l as N)	351.3
Bicarbonate (mg/l as $CaCO_3$)	Calculation
Carbonate (mg/l as $CaCO_3$)	Calculation
Bromide, Dissolved (mg/l)	320.1
Silica (mg/l)	370.1
Gross Beta (pCi/l)	--
Zicronium, Total (mg/l)	--
Beryllium, Total (mg/l)	210.2
Bismuth, Total (mg/l)	--
Geranium, Total (mg/l)	--
Gallium, Total (mg/l)	--
Specific Conductance (umhos)	--
Cesium 137, Total (mg/l)	--
Strontium 90 (mg/l)	--
Nitrate and Nitrite (mg/l)	Calculation
Total Organic Carbon (mg/l)	415.1
Thiocyanate (mg/l)	--
Dissolved Organic Carbon (mg/l)	Leenheer & Huffman Method
Fractionation of Organic Carbon into	
Hydrophobic Bases (mg/l)	Leenheer & Huffman Method
Hydrophobic Acids (mg/l)	Leenheer & Huffman Method
Hydrophobic Neutrals (mg/l)	Leenheer & Huffman Method
Hydrophilic Bases (mg/l)	Leenheer & Huffman Method
Hydrophilic Acids (mg/l)	Leenheer & Huffman Method
Hydrophilic Neutrals (mg/l)	Leenheer & Huffman Method

TABLE 8.5-11

Water Quality Parameter List and Typical Results from Seepage Monitoring Wells

1981 Water Year Average (mg/l)

	WW12*	WW13	WW22
T. Alk	110.0	386.4	82.25
Al	<0.100	<0.100	
NH_3	11.5	1.716	23.75
As	<0.020	<0.020	<0.020
Ba	<0.50	<0.50	
HCO_3	<1.0	318.75	<1.0
CO_3	97.0	71.625	54.0
BOD	38.5	32.5	
Br	<0.100	<0.100	
Hardness	150.0	850.0	
Na	75.0	206.0	172.5
Mg	17.0	74.7	23.25
Ca	11.0	32.5	77.2
Kjeld-N	12.0	1.48	32.75
Zn	<0.020	<0.020	
Pb	<0.020	<0.020	
Li	<0.050	0.06	
Mn	<0.020	0.24	0.015
Fe	0.03	0.128	3.775
F	0.09	<0.04	1.45
Mo	0.015	0.15	
Ni	0.0	0.005	
NO_3	<0.5	<0.3	<1.0
Oil	11.5	4.5	
Phenols	0.012	0.002	
K	3.9	4.05	42.0
B	0.1	0.25	0.2
TDS	450.0	951.6	982.5
Sr	0.5	2.4	
SO_4	240.0	430.0	
Cl	15.0	11.05	51.0
COD	27.5	0.15	
Cr	<0.020	<0.020	
Cu	<0.020	0.020	
DO	5.6	4.286	4.25
DOC	10.5	4.6	39.75
pH	8.95	7.7	9.375
Sp. Cond.	835.0	1408.57	1392.5
Temp.	11.25	16.25	18.0
SiO_2	<1.0	6.44	<1.0
Co	0.0	<0.020	
OH	10.0		

*Well recompleted 11/80, refer to WW22

TABLE 8.5-12

Water Quality Parameters Previously Analyzed in V/E Shaft Probe Holes

Aluminum	Bicarbonate	Ammonia - Nitrate
Arsenic	Carbonate	Oil and Grease
Boron	Chloride	
Calcium	Fluoride	
Iron	Nitrate	Phenols
Lead	Sulfate	Dissolved Oxygen
Magnesium	Total Alkalinity	
Manganese	Total Suspended Solids	
Potassium		
Sodium		

8.5.3.6 Raw and Processed Shale Piles

8.5.3.6.1 Introduction and Scope

During the development phase, raw and processed shale piles will be created on the Tract; these areas are shown in Sections 3.4 and 6.5. Pollution of surface water resources may be caused by storm runoff from these piles. Storm runoff may not only dissolve salts encrusted on the surface of these piles, but have the potential to carry particles and other pollutants to the streams. Field leaching studies have been initiated on a raw shale test pile in cooperation with the OSPO; historical parameters are given in Table 8.5-13.

It is expected that, under compliance with the future Mined Land Reclamation Permit, a monitoring plan of water quality sampling stations updip, downdip, on, and in the piles will evolve. Futhermore, SFC requirements for the monitoring of input waters and waste streams to the processed shale pile for non-regulated pollutants are expected to coalesce in the near future; a screening philosophy has been set forth in Section 8.13, Process Monitoring.

8.5.3.6.2 Objectives

To monitor the effects of the raw and processed shale piles on water quality of nearby resources of the state as required by future requirements of the Mined Land Reclamation Plan, and the Lease and SFC requirements.

8.5.3.6.3 Experimental Design

To date, the leachate collectors at Tract C-b have demonstrated that leachate will be produced from stockpiled raw shale. Studies also indicate that

TABLE 8.5-13

Constituents Analyzed in Raw Shale Leachate

pH	B	Cu
EC	Cd	Al
Alk	Be	Ca
H_2CO_3	Mg	Ba
HCO_3	P	K
CO_3	SI	Cr
F	Mo	Sr
Cl	Mn	Pb
NO_3	Ni	
SO_4	Na	

the quality of this leachate should be of negligible concern. CB expects that the findings of McWhorter (CSU) will further substantiate this fact.

Because the field tests at C-b have demonstrated the above findings, no specific monitoring plan is designed to monitor water movement through the raw shale stockpile. However, the erosion control basin, which will be constructed below the raw snale stockpile, will collect any leachate emigrating from the stockpile. Water collected in this basin will be sampled for water quality per the NPDES permit prior to being discharged.

In addition a water monitoring well will be located in the alluvium down-dip from the raw shale stockpile. This well will be sampled for water quality to determine if leachate from the pile is entering the groundwater, and if so, to determine the effects of the leachate on groundwater quality. The coarse ore stockpile in East No Name Gulch will be depleted in five years; therefore, control, if necessary, will be short-term.

Based on the water balance model no significant production of leachate is expected through the processed shale pile. In order to monitor water movement, a combination of techniques are planned: neutron probes, salinity sensors and fertility analysis.

Neutron probe access tubes will be placed near the edge (minimum of 20') and center of the pile. Moisture readings will be obtained at 2' intervals (total of ten/site) to determine water movement. Monitor wells completed above and below bedrock will be located up-dip and down-dip of the processed shale pile for each affected drainage.

Salinity sensors will be located near each neutron probe tube at depths of 12, 24 and 28 inches. In addition to moisture and salinity, fertility will be analyzed.

8.0 DEVELOPMENT MONITORING PROGRAM

8.5 Hydrology and Water Quality

8.5.4 Systems Dependent Monitoring

As in all other monitoring areas, depending on results and impacts obtained in this dynamic program, the numbers of stations, parmeters, and monitoring frequences are subject to change. This is called Systems Dependent Monitoring.

8.0 DEVELOPMENT MONITORING PLAN

8.6 Air Quality and Meteorology

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.6 Air Quality and Meteorology

8.6.1 Introduction and Scope

The Development Monitoring Program consists of two monitoring categories; basic and systems dependent. As applied to air quality, basic monitoring consists of 1) ambient monitoring, i.e., monitoring of surrounding conditions for both gaseous atmospheric constituents, total suspended particulates and visibility along with supporting meteorology and 2) emissions monitoring during operations. The systems-dependent category includes "triggering" of additional air quality stations or increased sampling frequency or incorporation of additional monitoring elements or all of these.

Because of the extended time period that the Development Monitoring Program covers and the changing development and operational phases, air quality monitoring must be regarded as dynamic. Number and location of sites, quantities sampled, sampling techniques, and sampling frequencies are subject to change with time inasmuch as it is a scientifically designed program, the results of which are subject to on-going analyses and cumulative judgements. This program attempts to address air quality impacts which are predicted before the fact and those which occur but were not predicted.

8.6.1.1 Monitoring of Regulated Pollutants

Categories of air quality regulations have been summarized on Table 6.2-2. Monitoring to date has consisted of regulated pollutants, i.e., those regulated by:

1) NAAQS - These "criteria" pollutants monitored include SO_2, NO_2, O_3, CO, and TSP. Pb is not expected to be present and has not been monitored. See Table 2.4-1 for comparisons with measured values at the Tract.

8.6 Air Quality and Meteorology

2) Colorado Ambient Standards - H_2S has been monitored at the request of the OSPO and State.

To date there have been no point emission sources on Tract with the exception of the cement batch plant which is a very small source. After start-up of commercial operations emissions monitoring will take place, consistent with requirements of New Source Performance Standards (see Table 6.2-4) and the Prevention-of-Significant Deterioration (PSD) permit (requiring Best-Available-Control-Technology (BACT)). See Table 6.2-6 for pollutants regulated under PSD and their de-minimus values; CB expected emission rates are also shown.

8.6.1.2 Rationale for Monitoring Non-Regulated Pollutants

The SFC has published environmental guidelines for synfuels for the monitoring of non-regulated pollutants. The guidelines refer to hazardous inorganic, organic and trace metals under a category called Supplemental Monitoring without being specific as to species. We propose emissions sampling for polycyclic aromatic hydrocarbons, heavy metals and hazardous pollutants on a limited time but statistically significant basis (as a Phase I) after start-up of operations. If and when species of sufficient magnitude are identified, we will continue to monitor them as a Phase II. Details are given in Section 8.6.4.

8.6.2 Ambient Air Quality

Three categories of the ambient air quality monitoring program include gaseous constituents, particulates, and area-wide visibility.

8.6.2.1 Gaseous Constituents

8.6.2.1.1 Objectives

The objectives of the ambient air-quality program are: a) to demonstrate compliance with applicable ambient air quality standards; b) to detect any long-term or seasonal trends in monitored variables; c) to identify sources of pollutants, in the event that levels of those pollutants are significantly above baseline levels, or are significant compared to ambient standards.

8.6.2.1.2 Experimental Design

Continuous monitoring of gaseous constituents in the ambient air on and near the C-b Tract includes measurements of the following:

Sulfur Dioxide (SO_2)
Hydrogen Sulfide (H_2S)
Ozone (O_3)
Carbon Monoxide (CO)
Oxides of Nitrogen (NO_x)
Nitrogen Dioxide (NO_2)
Nitric Oxide (NO)

Monitoring of these constituents is required under the Lease stipulations.

Methods of sampling these constituents utilizing continuous recorders are as follows:

Constituent	Technique
SO_2	Pulsed Fluorescent
H_2S	Pulsed Fluorescent

8.6 Air Quality and Meteorology

Constituent	Technique
NO_x	Chemiluminescent
NO	Chemiluminescent
NO_2	NO_x - NO
O_3	Ultraviolet
CO	Gas Filter Correlation Spectrometer

The analyzers in all stations utilize, where applicable, the EPA reference or equivalent methods.

The historical air quality network and that proposed for Development Monitoring are shown in Figure 8.6-1; operational timelines for this network are shown on Figure 8.6-2. The air quality trailer currently operational is located at Station AB23.

The proposed network for Development Monitoring consists of Station AB23 through 1985; thereafter it is replaced by Station AB24. Additionally, Station AB26 is expected to become operational in mid-1984. Baseline Stations AB20, AB21, AB22 and AB24 are currently discontinued. Parameters monitored are shown on Table 8.6-1 at sampling and reporting frequencies shown on Table 8.6-2; minimum data reporting frequency consists of one hour averages. One, three, eight, 24 hour and annual averages are computed as necessary for comparison with standards.

Station location and timing-of-operation rationale are as follows: Station AB23 and the meteorological tower have been in continuous operation since the start of the environmental baseline in November, 1974, and have provided long term trend information. Air-quality parameters monitored at that station include SO_2, H_2S, particulates, O_3, NO_x, NO, NO_2, and CO. Station AB23 is the most heavily instrumented trailer in that it is co-located with the 60-meter meteorological tower and contains all tower data channels. To date it has provided data under near-pristine conditions inasmuch as it is upwind of most of the development for the prevailing south-southwesterly winds. In 1980, particulate levels increased somewhat over baseline values. Because of this and

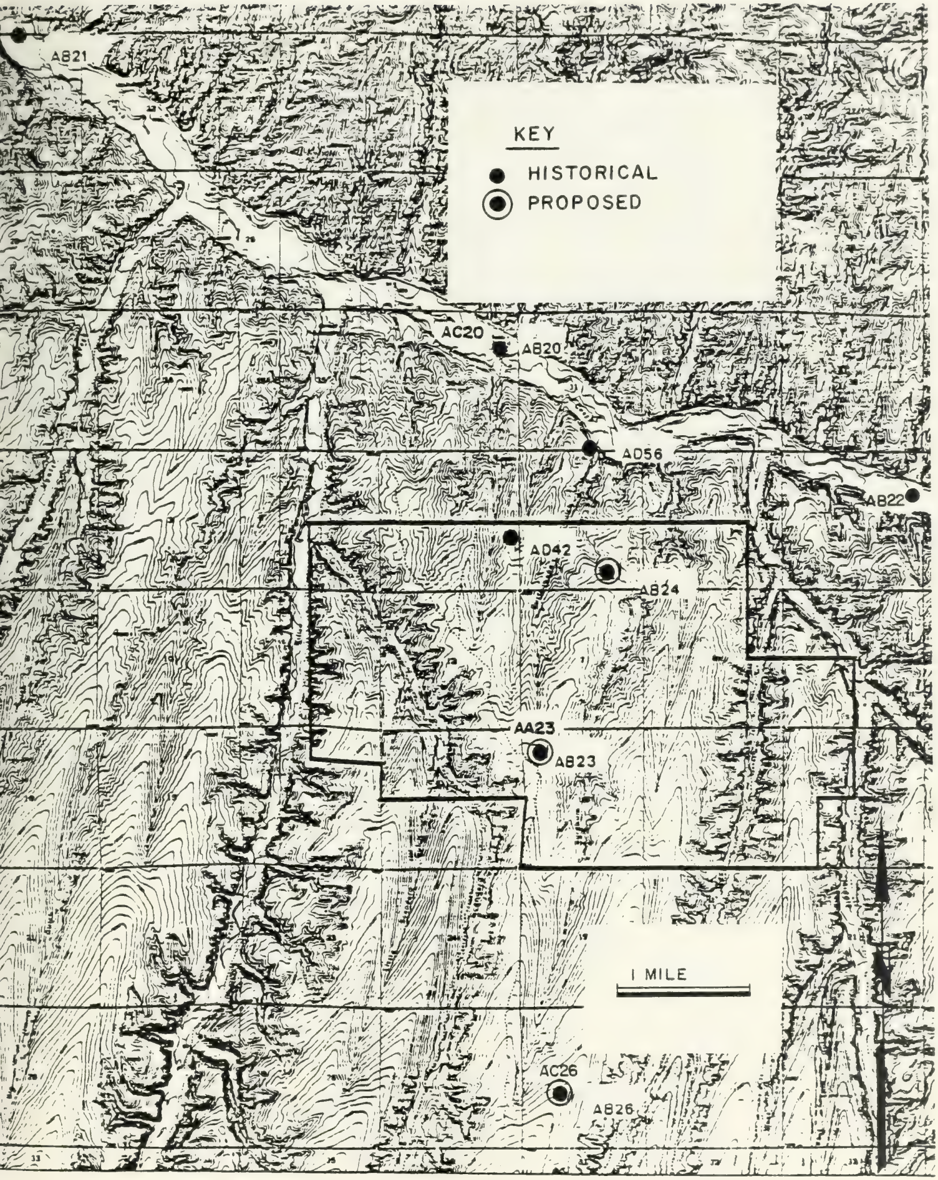


FIGURE 8.6-1

AMBIENT AIR QUALITY MONITORING NETWORK

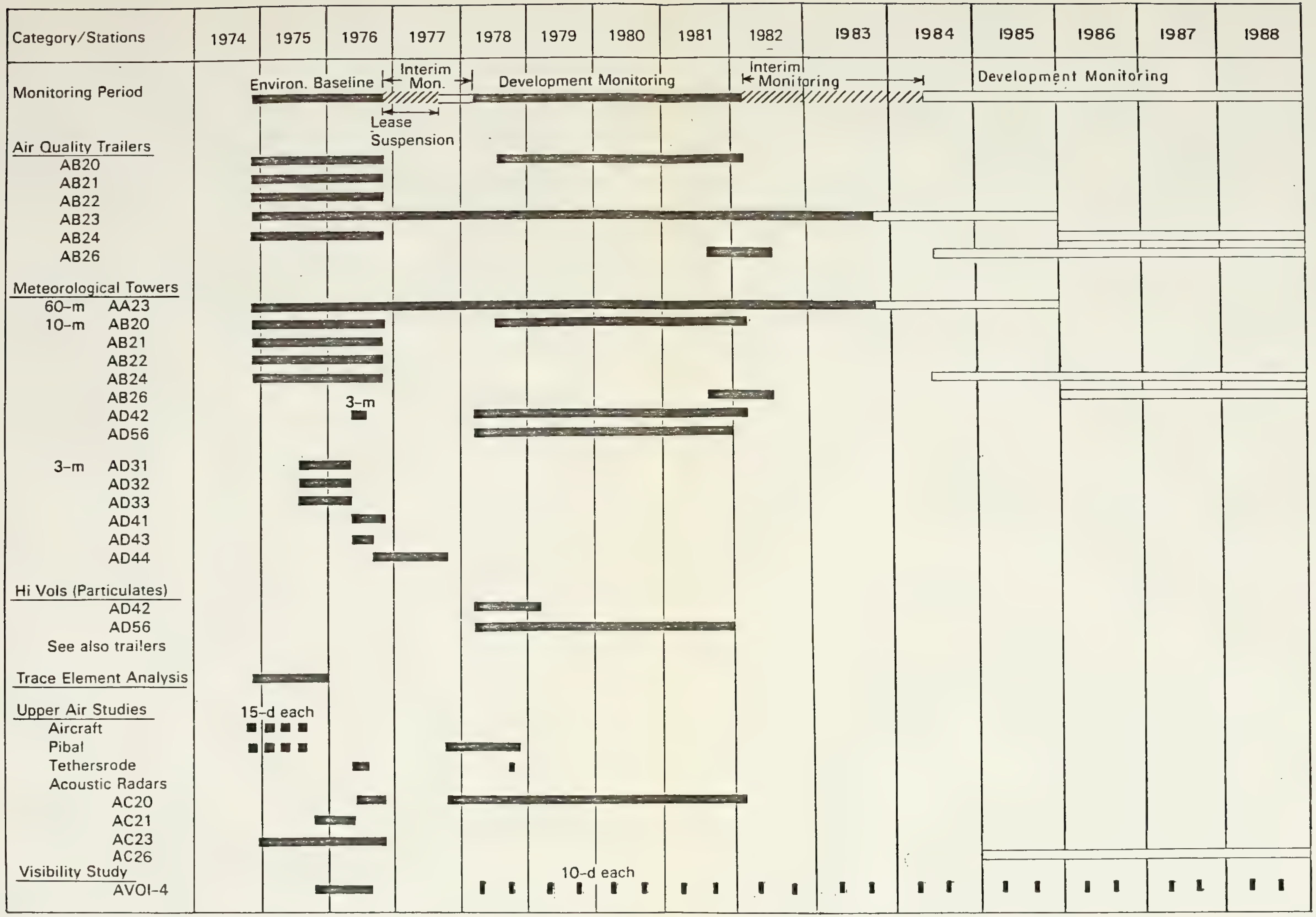


FIGURE 8.6-2
OPERATIONAL TIMELINES
HISTORICAL & PROPOSED
C-b AMBIENT AIR QUALITY
&
METEOROLOGY NETWORK

TABLE 8.6-1

Present and Proposed Ambient Air-Quality & Meteorology Data Description

Symbols represent sampling frequency on Table 8.6-2

Measurement: Category and Location	Start-up Date or Span	SO_2	H_2S	Particulates	Ozone	NO_x	NO	NO_2 (1)	CO	Horizontal Wind Speed	Horizontal (2) Wind Direction	Diffusion Coefficients	Relative Humidity	Air Temperature	Precipitation	Barometric Pressure	Solar Radiation	Temperature Difference	Mixing Height	Visual Range	Height
Air Quality Trailer																					
AB23	Nov. '74 - Jan. '86	X	X	0	X	X	X	X	Y						X	X	X				
AB24	Jan. '86	X	X	0	X	X	X	X	Y	X	X			X							
AB26	July '84	X	X	0	X	X	X	X	Y	X	X		X	X	X	X	X				
Met. Tower (AA23) @																					
3m	Nov. '74 - Jan. '86												X								
10m	Nov. '74 - Jan. '86									X	X			X				2			
30m	Nov. '74 Jan. '86									X	X			X							
60m	Nov. '74 Jan. '86									X	X			X				2			
Upper Air Studies																					
Doppler Acoustic Radar(4)	Jan. '85									U	U	X							U		U
Visibility, Sta. (3)	Apr. '78																			V	

(1) $(NO_2) = (NO_x) - (NO)$
(2) Std. Deviation Calculated.
(3) Sta. AV01-4

TABLE 8.6-2

Ambient Air Quality and Meteorology Sampling and Reporting Frequencies

Symbols appear on Table 8.6-1

Symbol	Sampling Frequency	Minimum Averaging Time	Minimum Reporting Frequency	Description
X	10-seconds	5-minutes	1-hour	AQ & Low Alt. Meteorology
Y	5-minutes	5-minutes	1-hour	AQ & Low Alt. Meteorology
0	Every 4th day	24-hours	24-hours every 4th day	Particulates
2	20-seconds	5-minutes	1-hour	Temp. difference from 10-meter to 60-meter on Met. Tower
U	14-seconds		1-hour	Inversion Height, Mixing Layer, Diffusion Coefficients, Velocity Components from Acoustic Radar
V	7 times per day every 6th day for 10 days in Spring and 10 days in Fall	Discrete Measurements	7 times/ day	Joint Visibility Study with C-a from Hunter Creek Site

because the development plot plan shows the Aboveground Retorting Facilities, the Surface Processing Facilities and the spent shale pile to be in the near vicinity of Station AB23 (i.e. "systems dependent" considerations) it was decided to initiate operations of Station AB26 in 1981, (but later temporarily discontinued under Interim Monitoring); Station AB26 will revert to operational status in mid '84 and established as the "control" station after sufficient parallel operations with AB23. It is sufficiently south of the Tract to be regarded as "pristine" under prevailing wind conditions. As of December 31, 1985 it is proposed to terminate AB23 and the meteorological tower. (See Section 8.6.3.) It is proposed to move trailer 023 and relocate it at site 024; 024 is a "small" trailer.

It is the intent to locate site AB24 near the predicted point of maximum impact; i.e. AB24 is to be the "development" or impact site. However, the following must be recognized:

1) Air diffusion models are relatively uncertain; and, as such, prediction of a point of maximum concentration is approximate at best.

2) The point of predicted maximum impact varies with both pollutant and averaging time. Annual-average cases are expected to be more reliable and will be given priority; the short-term cases are predicted to occur once or, at most, twice a year and then at a relatively uncertain location.

Therefore, although the location of the maximum impact point is not validated at present, temporarily it is assumed to be at the site of 024. Future rough terrain model runs and data analysis will be utilized to refine maximum impact point locations.

Additionally, site 020 which was terminated during Interim Monitoring is no longer required inasmuch as it is not located at the site of maximum impacts; it is useful only to monitor impacts from Piceance Creek road traffic.

8.6.2.1.3 Methods of Analyses

The analyses to be done not only vary with the objective, but with the constituent measured. For example, at least to the present time, H_2S, SO_2, the oxides of nitrogen, and CO have been at or near the minimum detectable limits of the instruments for the majority of the time. Therefore, extensive analysis for such cases is not warranted. Only for ozone and particulates have background values been consistently above zero values.

The first objective for ambient air quality was to demonstrate compliance with regulations. This is accomplished in tabular form by listing the standard by constituent, peak maximum readings obtained, along with associated date and station.

The second objective of detecting long-term trends is accomplished by a statistical test of the hypotheses:

H_o: Monthly means of each constituent do not change over time.

H_o: Annual means of each constituent do not change over time.

The technique usually used to test these hypotheses is linear regression analysis. In addition, the variables SO_2, H_2S, O_3, NO_x, NO_2, and CO are Class I indicator variables that are plotted as time series; histograms and concentration roses are utilized, as required. Between-station comparisons and correlations are also made to determine impacts or differences.

The third objective of identifying sources of pollutants is attempted (recognizing that source identification is a "guess", at best) via comparison of pollutant concentration roses with known sources in the vicinity. Another technique is to compare maximum and mean concentrations and their ratios, as follows:

8.6 Air Quality and Meteorology

A comparison of maximum and mean concentrations of air contaminants can provide some insight into the type of causative factors contributing to observed levels of those contaminants. There are three cases to consider: 1) the ratio of maximum to mean is close to one, and both maximum and mean values are low compared to ambient standards; 2) the ratio is close to one, but both maximum and mean are significant, compared to ambient standards; 3) the ratio is high, and the mean is low compared to ambient standards.

In the first case, the closeness of maximum-to-mean values indicates that the factors contributing to ambient concentrations are relatively consistent. Low levels observed indicate the absence of substantial contaminant sources near the monitoring site. Often, this situation is indicative of regional air contaminant levels in clear-air areas. Relatively minor local influences combined with highly dispersed contributions from distant sources result in stable, low levels of air contaminants.

The second case occurs most often when there is a geographical concentration of major sources of an air contaminant, or of air contaminant precursors, particularly where there is little variation in meteorology. This situation will almost always correlate with a high degree of urbanization or industrial development in the immediate vicinity of a monitoring site, or in an area consistently upwind of the site. The case not mentioned, i.e., that for which the ratio, maximum and mean are all high, would fit the same pattern of analysis, except for a higher degree of meteorological influence or more variable contributions.

The third case, a low mean value coupled with a high ratio, indicates the absence of nearby major stationary sources of air contaminants. Unlike the first case, however, the high ratio of maximum-to-mean is indicative of some major influence which is subject to time variation. Possible examples are short term effects of a portable source, relatively infrequent natural phenomena such as carbon monxide and particulates from forest fires, or stratospheric ozone injection to lower atmospheric strata. Absence of effects of nearby urbanization provides consistency of background levels.

8.6 Air Quality and Meteorology

All air quality data are entered into the computerized data base called RAMIS and retrieved therefrom for the CB six-month data reports to the OSPO. All data are also transmitted to the OSPO on computer tapes.

8.6.2.2 Particulates

8.6.2.2.1 Objectives

The objectives for particulate measurement are identical to those for gaseous constituents (Section 8.6.2.1.1).

Total suspended particulate measurements are required under the NAAQS for 24-hour and annual averaging times.

8.6.2.2.2 Experimental Design

The current particulate sampling network (Figure 8.6-1) currently consists of one station: AB23. Baseline stations AB20, AB21, and AB22 are discontinued. Station AB26 which was operational in 1981-1982 reverts to operational status in mid-1984. Station location and timing-of-operation rationale were discussed in Section 8.6.2.1.2 for compactness. Station locations are subject to change pending on new monitoring results and development requirements. Sampling and reporting frequencies are delineated on Table 8.6-2.

The EPA reference method for particulate monitoring, the hi-vol sampler, is employed at all stations with one 24 hour sample obtained every fourth day. It is expected that the particulates monitoring requirements will change in the near future with increased emphasis on the respirable fraction (particles less than 20 microns). When the standard is changed, the hi-vols will be replaced or augmented by newly EPA approved instrumentation, as required.

8.6.2.2.3 Methods of Analysis

The analyses to be undertaken vary with the objective and include time-series plots, single-and multiple-regression and correlation, histograms, and particulates-concentration roses.

8.6.2.3 Visibility

8.6.2.3.1 Scope

The visibility monitoring program has been cosponsored by the CB and Rio Blanco Shale Oil Projects. Measurements are taken during a total of ten days in the Spring quarter, and ten days in the Fall. There are no state or federal requirements for visibility monitoring; however, the program is required under the Federal Oil Shale Lease Environmental Stipulations.

8.6.2.3.2 Objectives

The objectives in taking visibility measurements are to establish baseline visual range for the Piceance Basin under relatively clear-day conditions for selected days during the Spring and Fall, and to attempt to establish correlations between visibility and meteorological or air quality parameters.

8.6.2.3.3 Experimental Design

Visibility data are obtained at an observation site about eight miles southwest of Piceance Creek on a ridge between Hunter Creek and Dry Gulch (Figure 8.6-3). The site was chosen for the range of views and targets available, the accessibility of the location, and its proximity to both C-a and C-b Tracts. Measurements are made at hourly intervals on ten days in the Spring and ten days in the Fall. Measurement days are selected to coincide with days when particulate samples are taken.

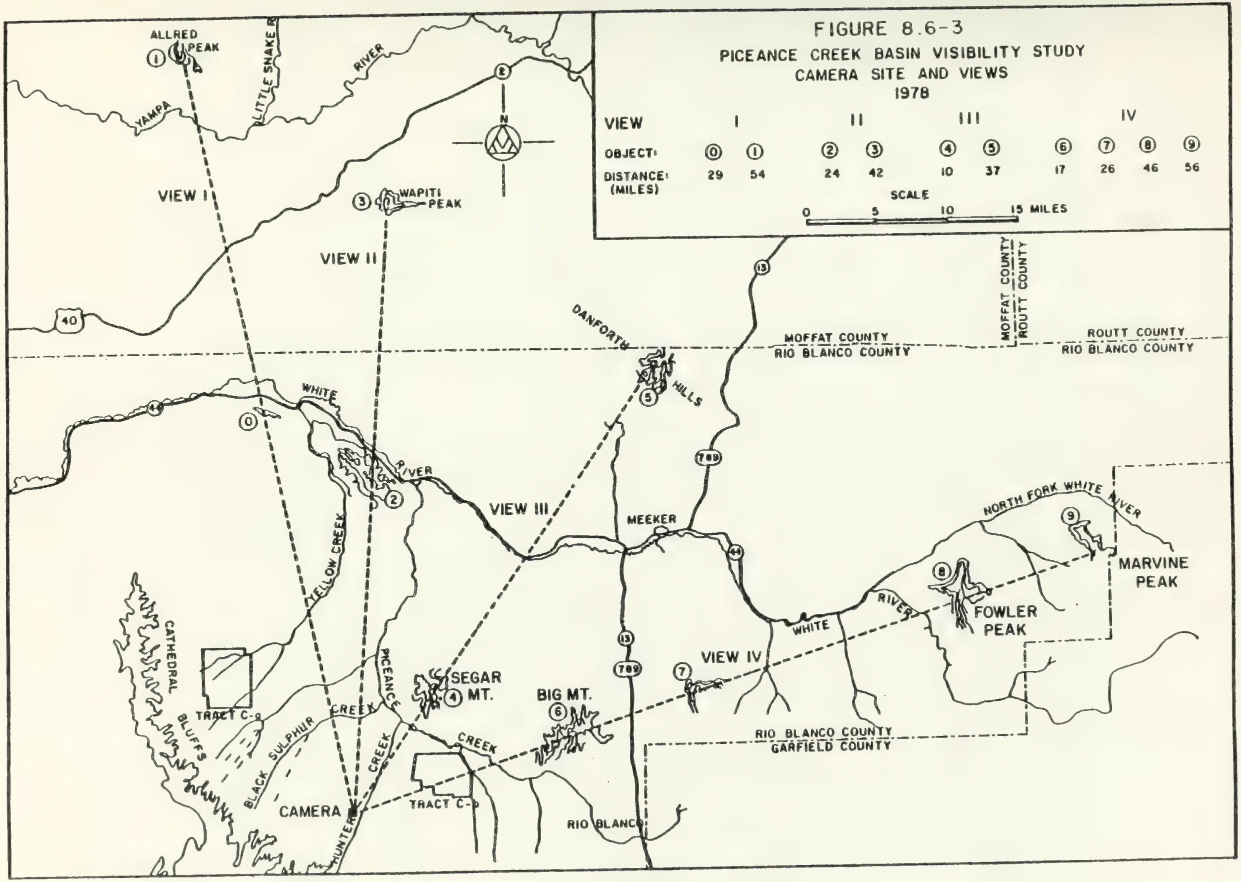


FIGURE 8.6-3
PICEANCE CREEK BASIN VISIBILITY STUDY
CAMERA SITE AND VIEWS
1978

8.6 Air Quality and Meteorology

The telephotometric technique is used to obtain visibility data. It utilizes natural targets along four different view azimuths as shown on Figure 8.6-3. The use of at least two targets in each view allows the estimation of visual range under different meteorological conditions. Radiance (contrast) values of the target and the background sky above the target are measured and used in calculating the visual range.

8.6.2.3.3 Methods of Analysis

Visual range results are compiled 7 times per day for each view; results are also averaged over all views daily and for spring and fall seasons to allow comparisons of data from the current year with data from baseline.

Standard correlation and multiple regression techniques are used, as appropriate, to evaluate potential relationships between visual range and meteorological or air quality data. Histograms are utilized to depict visual range statistics.

8.6.2.4 Dry and Wet Deposition

Referring to Section 6.2.4.4, it has been estimated that the CB Project will have no impact of acid deposition on Air Quality Related Values (AQRV's). However, at precipitation Station WD28 on-Tract, periodic pH assessments of the rainfall will be made. Furthermore, CB is participating in group efforts on the part of API and RMOGA to support acid-rain research. Specifically, the work of John Turk of the USGS on high altitude lakes with relatively low buffering capacity in the Flattops Wilderness region has been supported through API and USGS funds.

8.6.3 Meteorology

8.6.3.1 Climatological Records

8.6.3.1.1 Scope

The climatological parameters measured include temperature, solar radiation, precipitation, relative humidity and barometric pressure. These records primarily serve as a historical data base to assess climatological effects principally on the biotic portion of the ecosystem so they may subsequently be differentiated from potential man-induced effects.

8.6.3.1.2 Objectives

Objectives are to establish this historical data base and to determine any cyclical or long-term trends that might exist as well as averages and extremes, as appropriate.

8.6.3.1.3 Experimental Design

Historical sampling stations and those proposed for Development Monitoring are shown on Figures 8.6-4 (on- or near-Tract) and 8.6-5 (off-Tract). A new station, AD28, at the raw shale leachate study pile has recently been added; Station AB26 will revert to operational status in mid-1984. Stations dropped for Development Monitoring are AB20 and microclimate stations BC01, BC02, BC04, BC06, and BC08. Thus the proposed network of C-b monitored stations would include AB23, AB26, AB28, BC03, BC05, BC07, BC09, and BC13. Remote off-Tract stations are monitored by the USGS. Instrumentation used, sampling stations, and minimum reporting frequency are presented in Table 8.6-3.

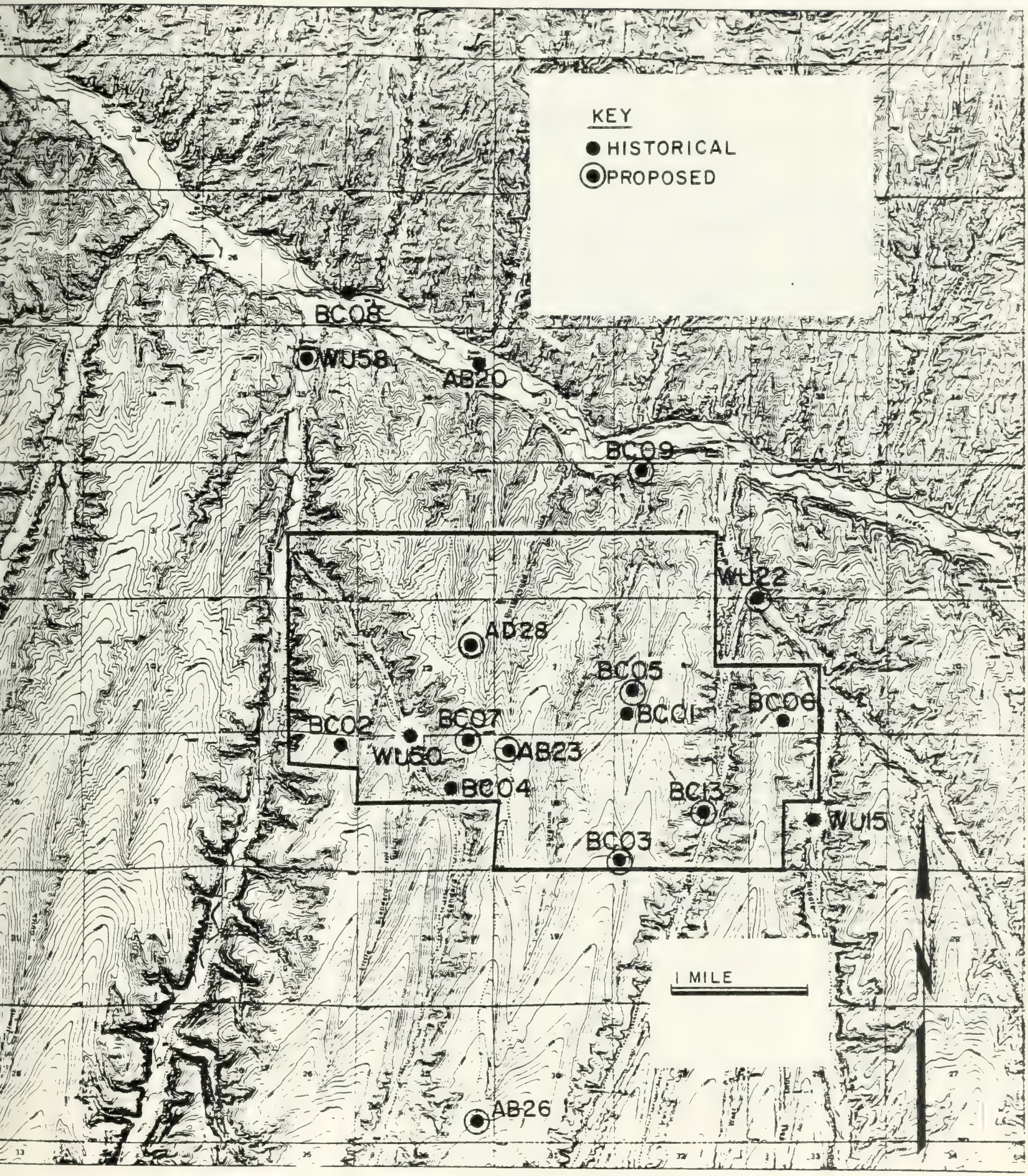


FIGURE 8.6-4
CLIMATOLOGICAL NETWORK NEAR TRACT

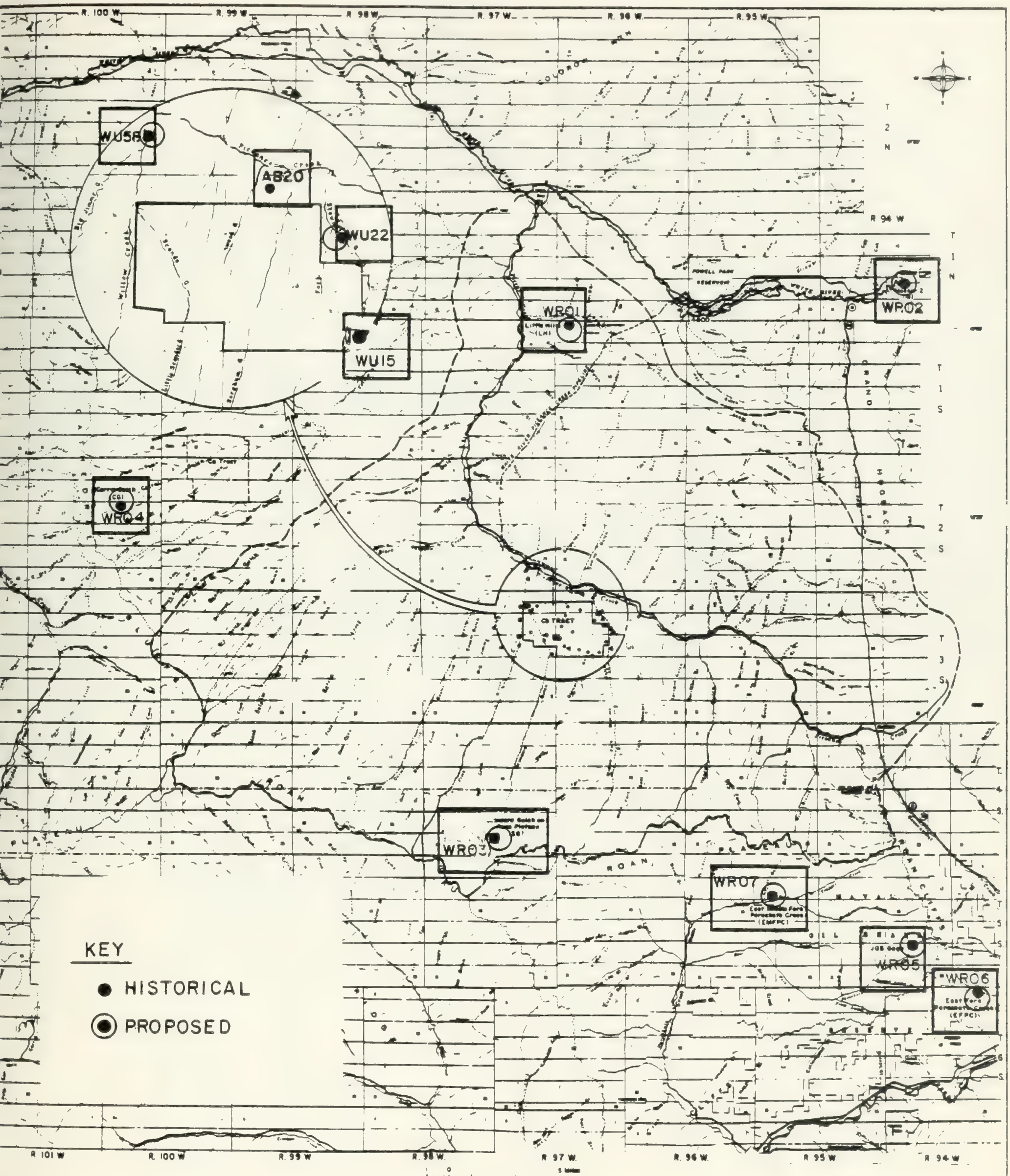


FIGURE 8.6-5
CLIMATOLOGICAL NETWORK OFF-TRACT

TABLE 8.6-3

Climatological Parameter Experimental Design

Parameter	Instrument	Station(s)	Computer Code	Minimum Reporting Frequency
Air Temperature	Aspirated Temperature Sensor	023	AB23	Hourly
Direct Solar Radiation	Pyranometer	023	AB23	Hourly in Daylight
Precipitation	Weighing Bucket	023	AB23	Hourly
	Weighing Bucket	026	AB26	Hourly
	Weighing Bucket	028	AD28	Hourly
	Storage Bucket	USGS015*	WU15	Approximately Monthly Totals
	Storage	USGS022	WU22	Approximately Monthly Totals
	Tipping, Weighing, Storage	USGS050	WU50	Approximately Monthly Totals
	Storage	USGS058	WU58	Approximately Monthly Totals
	Weighing Bucket	Little Hills	WR01	Daily
	Weighing Bucket	Meeker 2	WR02	Daily
	Weighing Bucket	Scandard Gulch on Roan Plateau	WR03	Hourly
	Highway Intensity, Weighing, Tipping	Corral Gulch	WR04	Hourly
		JQS Gage	WR05	Hourly
	Weighing Bucket	East Fork Parachute Creek	WR06	Hourly
	Weighing Bucket	East Middle Fork Parachute Creek	WR07	Hourly
	Tipping Bucket	MC3, 5, 7, 9, 13	BC03, BC05, BC07, BC09, BC13	Bi-weekly
Relative Humidity	R. H. Sensor	023 026	AB23	Hourly
Barometric Pressure	Barometer	023 026	AB23	Hourly

* Proposed to be dropped.

8.0 DEVELOPMENT MONITORING PLAN

8.6 Air Quality and Meteorology

8.6.3.1.4 Methods of Analysis

Data presentation and analysis techniques include linear and multiple regressions, histograms, plots and tables. Time-series plots for Class I indicator variables are included in the CB six-month data reports.

8.6.3.2 Wind Fields

8.6.3.2.1 Scope

Wind field data are currently collected at the meteorological tower. Data consist of wind speed, wind direction, vertical variations in horizontal wind speed and wind direction (from differences at 10m, 30m, and 60m heights) and stability class. Wind flow patterns and stability class provide information for diffusion modeling and pollutant transport and concentration.

The operational timelines for the meteorological network are shown on Figure 8.6-2. It is proposed to initiate the 10-m meteorological tower on Station AB26 in mid-1984 and to acquire a Doppler acoustic radar at AB26 in January 1985 (and called Station AC26) so as to provide one full year of concurrent data with the 60-m meteorological tower at Station AA23. It is then proposed to terminate Station AA23, the 60-m tower, as of January 1, 1986 and retain the Doppler acoustic radar.

8.6.3.2.2 Objectives

The objectives of this program are:

a) to refine the knowledge of the wind fields in the vicinity of the C-b Tract,

b) to provide supporting information for air quality data analysis, and

c) to provide inputs for air diffusion modeling.

8.6.3.2.3 Experimental Design

Sampling frequency for wind data is identical to that of the air quality parameters. Variables measured at the present stations and instrumentation used are shown in Table 8.6-4.

Near-surface wind fields are determined from continuous monitoring of winds at the 10 meter height. Measurements over three meteorological-tower levels along with historical acoustic radar and pibal trajectories provide data for vertical wind structure and stability conditions important for determining plume rise and for diffusion modeling.

8.6.3.2.4 Methods of Analysis

Analysis consists of comparisons of wind field data over time and between sites. Temporal comparisons are made by comparing quarterly wind roses over several years at a given site and elevation. Seasonal differences are then noted. Spatial comparisons consist of comparisons of wind roses collected at different sites.

8.6.4 Emissions Monitoring

It is expected that the EPA and the State Air Pollution Control Division will require stack emissions monitoring of regulated pollutants under New Source Performance Reviews and State New Souce Performance Standards. These are discussed in Section 8.6.4.1. Additionally, the Synthetic Fuels Corporation, under their environmental guidelines for the synfuels industry, requires additional monitoring of unregulated pollutants. These are discussed in Section 8.6.4.2.

8.6.4.1 Air Emissions Monitoring of Regulated Pollutants

As previously mentioned, Federal NSPS do not exist for oil shale. However, under BACT requirements of the present PSD permit and the APEN permit, continuous stack emissions monitoring is required as indicated in Table 8.6-5. EPA, Region VIII, has also given preliminary recommendations for SFC monitoring of unregulated pollutants as shown in the lower part of Table 8.6-5; these are subject to change.

8.6.4.2 Air Emissions Monitoring of Unregulated Pollutants

Emissions from the MIS offgas fired boilers are the only sources that have the potential to emit unregulated pollutants in quantities that could be of any possible significance. The MIS offgas fuel is a low BTU gas of 65 BTU/SCF which burns at a lower temperature than fuel gas of a more normal heating value, 500-1000 BTU/SCF. The lower combustion temperature of the MIS boilers has the potential of forming polycyclic aeromatic hydrocarbons some of which are health hazards. Emissions from the MIS boilers will pass through double alkali scrubbers which will remove acid gas components such as SO_2 and enter the atmosphere. Samples of the flue gas will be taken after the scrubbers in accordance with EPA procedures for stack sampling of particulate and gaseous components. Particulates collected will be analyzed for heavy metals using standard EPA analytical methods. A portion of the particulate samples will be solvent extracted and analyzed for polycyclic aromatic compounds in accordance with EPA approved methods. The gas sample will be analyzed for SO_2, H_S, RSCH, As, Hg, Pb, Cd, Se, B, and HCN.

These analyses would be done on a limited time basis (but with statistical significance) after the plant achieved steady state operation such that a nominal sample can be drawn (called Phase I). Then the analytical results will be reviewed and if a hazardous pollutant is found in significant concentrations, it

TABLE 8.6-5

EPA Region VIII's Emissions Monitoring Requirements for CB Under PSD and Preliminary SFC Recommendations

Requirement	Source	Type of Sample	Species
PSD	Fuel Gas from Unisulf unit	Continuous	Total S (expressed as elemental sulfur), H_2S
"	Scot Tail Gas Incinerator	Continuous	Total S (expressed as SO_2)
"	Reformer Furnace	Continuous	Nitrogen Oxides (expressed as NO_2 in lbs/MM Btu)
SFC	FGD (outlet)	Grab	Organics
"	MIS Offgas just ahead of the Boilers	Grab	H_2S, Organics, Metals
"	Deasher Water Effluent	Grab	Organics, Metals
"	Water to Retorted Shale	Grab	Organics, Metals
"	FGD Sludge	Grab	Organics, Metals
"	Retorted Shale	Grab	Organics, Metals
"	Retorted Shale Pile (Wells)	Grab	Organics, Metals

may be necessary to undertake a regular monitoring program to track it (called Phase II). However, if no hazardous pollutants are identified to exist at significant concentrations, then only regulated pollutants would be monitored in accordance with our permit conditions.

In addition to these air emissions from the FGD, Table 8.6-5 also lists additional effluent streams suggested to be sampled under SFC guidelines.

8.6.5 Air Diffusion Modeling

8.6.5.1 Model Validation

The site-specific rough terrain model developed by Aero-Vironment and previously documented is hereby incorporated by reference. It is regarded as being completely validated through the SF_6 tracer tests and model validation results previously issued.

The Lessee has agreed to investigate feasibility of injecting known amounts of SF_6 tracer gas into process exhaust stacks after initial retorts are operating for a short test of plume dispersion under actual operating conditions. Ambient concentrations at specified installed receptors designed especially for low SF_6 concentrations would then be measured as time histories following the releases. Experimental details will be finalized in 1985.

8.6.5.2 Cross References to Modeling Results

Modeling results are discussed in the Air Quality Control Plan, Section 6.2.

8.6 Air Quality and Meteorology

8.6.6 Systems Dependent Monitoring

Figure 8.6-1 shows air quality trailers at Stations AB20, AB21, AB22 and AB24 which are not now activated. Furthermore, Station AB26 is in the process of being reactivated in mid-1984. In the event that unforeseen high concentrations are measured at existing stations, additional stations could also be activated. Station AB22 has been moved and is currently used for storage. It is also possible that because of changed location of major stacks from initial to operational phases, shifts in predicted (via model) concentrations or in actual peak concentrations can occur. Mutual concurrence with the OSPO and the EPA would be obtained prior to any such additional station activation or for shutdown or relocation of any operational station(s).

8.0 DEVELOPMENT MONITORING PLAN

8.7 Noise

TABLE OF CONTENTS

FIGURES

8.0 DEVELOPMENT MONITORING PLAN

8.7 Noise

8.7.1 Introduction and Scope

The environmental noise program conducted during Baseline was not required under the Lease, but was requested by the OSPO. General background noise levels were sought on the Tract and surrounding vicinity prior to Tract development.

Measurements were made during Baseline, one working day per month for approximately one hour at 14 locations over a 14 month span starting in September, 1975. A General Radio 1565 sound level meter has been used to obtain measurements at A, B, and C weightings.

Measured noise levels (A weightings) above background along Piceance Creek Road were always made in the presence of passing vehicles. The traffic noise analysis contained in the Final Baseline report indicated an average level at a station on Piceance Creek Road near Hunter Creek to be 53 dbA which was exceeded 10 percent of the time. Peak noise level was 83 dbA from a road scraper in July, 1976.

On-Tract activity diminished from December, 1975 to almost zero in 1976 in terms of Tract noise level. Noisiest activity at any Tract boundary (East) was that due to a well jet test in November and December, 1975 producing up to 75 dbA.

On the basis of low noise levels existing during Baseline, discrete measurements were terminated at all but two locations. Instantaneous measurements at these two stations continued through December, 1980. At that time, with OSPO approval, they were terminated in favor of 24-hour continuous measurements subsequently described. Noise measurements were terminated in January 1982 with OSPO approval for the Interim Monitoring period.

8.7.2 Environmental Noise

Aspects of environmental noise treated here deal with traffic- and Tract-generated noise levels. It is to be expressly noted that occupational noise exposure is discussed under Section 6.15, Health and Safety.

8.7.2.1 Traffic Noise

8.7.2.1.1 Objective

To measure traffic noise levels due to development.

8.7.2.1.2 Experimental Design

Continuous traffic noise measurements are made every 6th day at Station NB01 (Figure 8.7-1) adjacent to the access road at the northern Tract boundary. The sensor is discussed in Section 8.7.2.2.2. This Development Monitoring Program will be initiated in mid-1984.

8.7.2.1.3 Method of Analysis

This is identical with 8.7.2.2.3.

8.7.2.2 Tract Noise

8.7.2.2.1 Objectives

The objectives of the Tract noise study are 1) to evaluate increase in Tract noise due to development, and 2) to demonstrate compliance with State noise regulations.

State noise standards for an industrial zone are as follows in terms of maximum allowable noise levels:

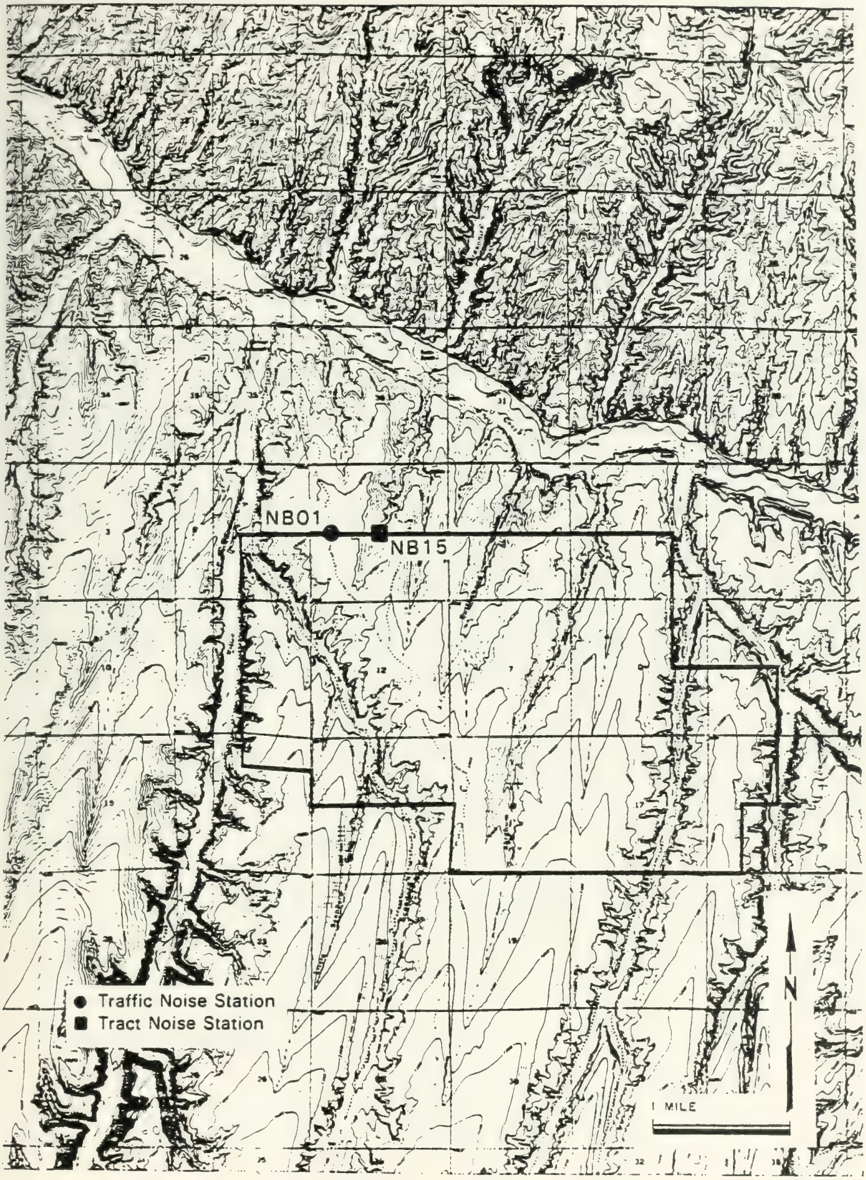


FIGURE 8.7-1
NOISE ENVIRONMENTAL MONITORING NETWORK

8.7 Noise

Steady	80 db(A)	7am to next 7pm
	75 db(A)	7pm to next 7am
15 min. in any one hour:	90 db(A)	7am to next 7pm
Periodic, impulsive, shrill:	75 db(A)	7am to next 7pm
	70 db(A)	7pm to next 7am

These standards apply within 25 feet of the property line (Tract boundary). The Tract has not been classified industrial at this time. Rural areas do not have such standards. The County may be disposed to classify the area for energy use in the future.

8.7.2.2.2 Experimental Design

During early phases of development most activity occurs near the north-central portion of the Tract. Most ranches are located north of the Tract. Thus a noise monitoring site on the northern boundary is most appropriate for monitoring noise levels on the Tract due to development.

Continuous noise measurements are to be made during Development Monitoring at Station NB15 (Figure 8.7-1) on the northern boundary of the Tract in near proximity to the V/E shaft for 24 hours every sixth day. The sensor recording system consists of the following:

Sound Level Meter (SLM) with 15/16" Microphone and Recorder
Portable Acoustic Calibrator
Microphone Rain Cover
Wind Screen with Spikes
0.5" Dehumidifier

In this model the SLM is coupled to the battery operated recorder for 24 hours of unattended all-weather operations at an A weighting.

The SLM is calibrated before each day's use with its portable acoustic calibrator. The recorder is calibrated before and after each day's use. Thus any drifts are readily apparent. Time references are annotated before and after operation.

8.7.2.2.3 Method of Analysis

Twelve-hour peaks (7am - 7pm and 7pm - 7am) are reported and plotted as a time series along with averages and backgound levels for each day of observations. Peak values are compared with standards for an industrial zone as referenced in Section 8.7.2.2.1.

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

8.8.1 Introduction and Scope

The principle aim of the biological monitoring program is the continued evaluation of biotic conditions, and their interaction with abiotic conditions in the Tract C-b ecological systems. This effort is concerned with the identification of trends and/or changes in system variables and processes, the identification of causes for change, and the mitigation of such effects where appropriate. Individual studies will focus on the collection of data on biotic variables and processes selected through the application of the criteria explained in each Section Introduction.

The selection of the key variables and processes focuses on components of the Tract C-b system that are important to system function (see Table 8.8-1). Moreover, the majority of the variables chosen are those that provide information relative to early warning indication of system change. The hypotheses-testing approach effectively assures that significant changes will be detected through proper and appropriately rigorous data analysis.

The basic design of the monitoring program is the study of control (non-affected) sites and developmental (potentially affected) sites. The use of control and developmental sites permits the monitoring of long-term trends at affected and non-affected sites, and the analysis of any corresponding differences over time developing in these sites. Secondly, by applying testing procedures to control and developmental sites in any given year, differences and their probable causes can be detected. By this approach oil-shale-development-related changes can be segregated from naturally occurring changes. Monitoring sites for Interim Monitoring are shown in the CB data reports; those proposed for Development Monitoring will be available in mid-1984.

TABLE 8.8-1

Variables for C-b Biological Monitoring Program

VARIABLE	SAMPLING PERIOD AND/OR INTENSITY	APPROXIMATE STARTING DATE
Deer:		
Pellet Groups	Once per year in chained pinyon-juniper rangelands and pinyon-juniper woodlands.	June 1
Browse Production and Utilization	Twice each year along 31 transects used also for deer-day use.	June and September
Migrational Patterns and Phenology	Mid September through May - Highway 64 to Rio Blanco.	September 15
Natural Mortality	Once each year in spring in ten lateral draws and bottomland sagebrush north of Tract.	June 1
Age-Class Composition	Twice each year in fall and spring in meadows adjacent to the Tract.	November and April
Medium-Sized Mammals:		
Lagomorph Abundance	Twice each year in the chained pinyon-juniper rangelands and pinyon-juniper woodlands using the deer pellet group transects.	June 1
Small Mammals:	Once each year early fall in chained pinyon-juniper rangelands, pinyon-juniper woodlands.	August 15
Avifauna:		
Songbird & Mourning Dove Relative Abundance and Diversity	Three times each May during the peak breeding season in pinyon-juniper rangelands and pinyon-juniper woodlands.	May 15
Raptor Activity	Twice each year during the appropriate breeding season nest occupancy will be checked. Also, throughout the year all raptor sightings within the study boundary will be recorded.	April and June
Aquatic Ecology: Benthos Periphyton	Monthly - except in winter when inaccessible and low biologic activity.	May through October

TABLE 8.8-1 (Cont'd)

Variables for C-b Biological Monitoring Program

VARIABLE	SAMPLING PERIOD AND/OR INTENSITY	APPROXIMATE STARTING DATE
Terrestrial Vegetation: Community Structure and Composition	Two-year rotational sampling for the chained rangeland and pinyon-juniper vegetation types. After sampling the first two-years the development zone will be sampled the same years as the chained rangeland type.	Mid-June
Vegetation Productivity and Utilization	Once each year in a total of 72 paired plots (range cages and open areas), 24 pairs in each of chained rangeland and pinyon-juniper vegetation types and 24 in the development zone.	Mid-July
Revegetation	Once each year beginning with the third growing season for areas greater than one acre in size.	July
Revegetation Demonstration Plots	Once each year beginning the first growing season.	July
Systems Dependent Monitoring	When "triggered."	
Special Projects	As needed.	
Micro-Climate Studies	Twice monthly at ten baseline sites.	January 1

8.8 Biology

In order to better interrelate the vegetation and wildlife studies and to assist in the evaluation of development activities, both will be expanded to incorporate the immediate vicinity of the planned development sites. The zone to be measured will be an area within 200 meters of the development areas. Control transects will be at least 800 meters away from the development areas. The transition zone (200-800 meters) will only be sampled if related impacts are noted in the 200 meter zone. Both vegetation and wildlife studies will be established along the same transects facilitating better correlation of the studies.

Data collected will be subjected to statistical treatments. Statistical comparisons to be used are indicated in the appropriate Sections.

A significant difference is defined for each program at a level for which the stated null hypotheses can be accurately tested. Levels of significance are broad enough to absorb natural fluctuations, as observed during baseline studies in the specific population studied, but limiting enough to reject the null hypothesis when abnormal fluctuations are discovered. A null hypothesis rejection leads to an action decision which usually involves more intensive studies. Time-series analysis may also be used in some cases.

8.8.2 Big Game: Mule Deer

Big game refers primarily to mule deer, since they are the only large mammals common to the C-b Tract area apart from domestic cattle. Intensive

studies of mule deer are justified since deer are a major herbivore of ecological importance and a game species of economic importance. In addition, they are vulnerable to impact from development activities, road kill, increased hunting pressure and climatic changes.

Monitoring of mule deer attempts to show the significance of Tract C-b activity vs. measurable population dynamics. This is accomplished through analysis of the following variables: 1) deer pellet group densities, 2) browse production and utilization, 3) migrational patterns and phenology, 4) road kills, 5) natural mortality, and 6) age-class composition. Mule deer analysis will also include professional evaluation of cattle/deer interrelationships through herbaceous production/utilization, season of use etc., hunting pressure/success, and correlation with regional deer information. Study transects and sample sizes are based on baseline experience.

8.8.2.1 Deer Pellet-Group Counts

8.8.2.1.1 Scope

Deer pellet-group counts will be conducted along approximately 51 transects. This represents a possible 12 transect expansion from the existing program. The additional transects will be placed adjacent to the new development sites.

8.8.2.1.2 Objectives

The objective of pellet count studies is to monitor distributions of wintering deer on and in the near vicinity of Tract C-b. Changes over time are evaluated to test for differences due to development-related activities. Of

particular importance is evidence for displacing deer to nearby off-site areas, or attracting deer to habitat improvement areas.

8.8.2.1.3 Sampling Design

Permanent pellet-group transects have been operative on Tract C-b since 1978. These transects were positioned using a stratified random sampling design for on-site chained rangeland and pinyon-juniper habitats, and a systematic sampling design for nearby, off-site areas. Since 1978, additional transects have been added to investigate the success of various habitat improvement programs. Most of these additional transects are still operative, and in 1982-83 pellet data were obtained along 39 transects. All transects consist of twenty, 0.01 acre plots spaced at 15m intervals (see Figure 8.8-1). Pellet-groups are counted and swept from quadrats once each year during spring.

The proposed addition of up to 12 more transects is to insure that adequate sampling is conducted in close proximity to the new shale disposal locations. As well, this particular array of transects will be part of an interrelationship monitoring program, which is described in detail in Section 8.8.2.7, Interrelationships.

8.8.2.1.4 Method of Analysis

The hypothesis to be tested is:

H_0: No difference exists in deer pellet densities between control and developmental sites.

Since 1978 the results of deer pellet-group counts have been used to characterize spatial distribution of wintering deer on and near Tract C-b, and to statistically test for suspected development-related changes in these distributions. Estimates of deer pellet-group densities, therefore, are being

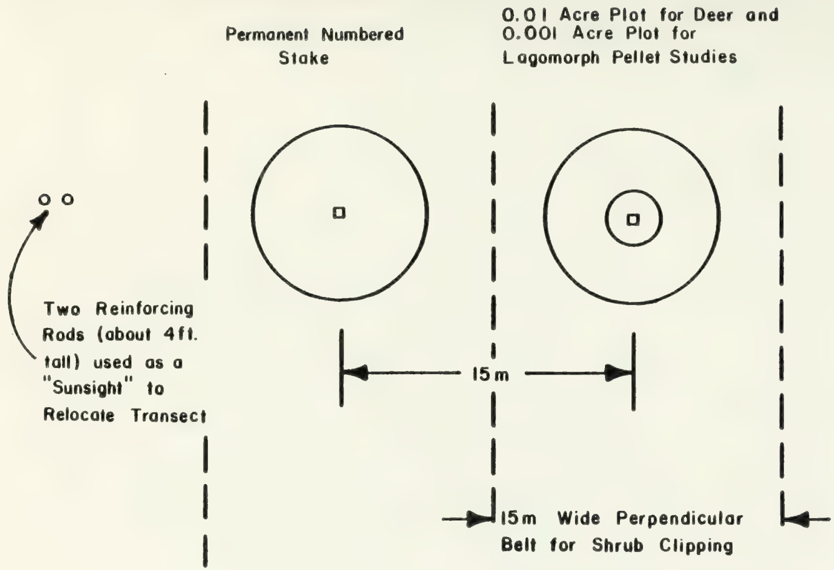


FIGURE 8.8-1
PELLET GROUP TRANSECT DESIGN

used as an index of deer abundance. It is assumed, for example, that if deer are displaced from a disturbance area (e.g., an active construction site) that this displacement will be manifested in a change in pellet-group distributions. No assumption is made regarding the extent to which pellet-group distributions reflect habitat use, particularly forage utilization, although correlations are routinely made between pellet data and browse utilization data (see Section 8.8.2.7, Interrelationships).

The null hypothesis will be tested at a level of significant of $\alpha = 0.05$. Testing for a significant difference between control-treatment ("control-development") sites is usually not a straightforward statistical procedure. Tests in the past have typically been comparisons between one or several transects in close proximity to an unanticipated disturbance area, and all other transects which, at that point in time, serve as controls. One test that has been developed and successfully used is as follows: differences between the mean of each control transect of the current year and the means of all previous years are calculated and expressed as normal deviates ($Z = (X-\overline{X})/SD$). Differences at development sites (suspected impact sites, or habitat enhancement sites) are then compared to a table of normal deviates to obtain the probability of randomly choosing such values. The validity of the method depends on the accurancy of the means of all previous years (hence, the more baseline years the better) and a normal distribution of difference values (hence, the more control transects the better). Other tests are of course possible depending on the situation. For example, the additional 12 transects that are proposed will be arrayed around new developmental sites including the shale disposal sites. This arrangement will permit a comparison between the area prior to operations and afterward. An appropriate test for an impact occuring in the zone closest to the shale pile is the interaction F-test of a 2-way analysis of variance.

Raw data from pellet-group studies (as well as all other studies) are examined for normality and homogeneity of variances. Transformations are used as appropriate. Typically the logarithmic transformation is used with pellet-group data.

8.8.2.2 Browse Production and Utilization

8.8.2.2.1 Scope

Bitterbrush browse production and utilization are currently being evaluated along 19 transects, 13 in chained rangeland and 6 in pinyon-juniper woodland. Browse studies occur along the same transects that are used for pellet-group studies, although not all the pellet-group transects are used. The additional 12 transects proposed will be used for browse studies as well, increasing the number of transects to 31.

Sagebrush utilization will be based on ocular estimations along the deer-pellet transects. Twenty-five transects are sampled.

8.8.2.2.2 Objectives

Objectives of bitterbrush studies are to estimate the current annual growth of browse that is available as forage to deer (yield), and to estimate the percentage of this yield that is consumed by deer. The sagebrush studies also yield data on deer use of browse along with age class data on sagebrush plants. All these estimates are valuable in characterizing browse intensity as well as patterns of utilization. Also, they provide a second approach (in addition to deer pellet-group counts) for detecting development-induced changes in the distribution of the local deer population.

8.8.2.2.3 Sampling Design

Bitterbrush production and utilization methods consist of randomly selecting ten bitterbrush shrubs along each transect during the fall. A stem on each shrub is randomly chosen and the current annual growth of ten shoots along the stem are measured. This provides an estimate of production (yield) of available forage in terms of a length measurement. During spring, after deer have moved to summer

range, each shrub is returned to and the same shoots are again measured. The length of shoots consumed by deer provides the estimate of utilization.

An expansion in this program is currently planned whereby production of available bitterbrush forage may be estimated on a weight basis. This work will be conducted only along the additional 12 transects proposed for the new development sites.

The sagebrush ocular estimates are conducted in the spring along the deer pellet-group transects. The sampling interval is two or three paces depending on browse density along the transect. At each sample point, the tally is recorded by age class and hedging class of the shrub whose outer perimeter is nearest the boot toe. Sample size will vary from 25 plants in the pinyon-juniper habitat type to 50 plants in the chained pinyon-juniper type.

The following description will be used in classification: (BLM sampling technique):

AGE CLASS (Sagebrush)

Y -- Established seedlings and young plants. Elongate growth form, simple branching; usually less than six years old, and basal stem diameter not over 1/4".

M -- Mature plants. Distinguished by heavier, often gnarled stems, complex branching, round growth form. Crown made up of more than three-fourths living wood.

D -- Decadent plants. Crowns made up of more than one-forth dead wood.

DEGREES OF HEDGING

L - Little or no hedging, indicating light use in the past three or four years. Growth tends to be linear.

M -- Moderately hedged. Moderate use in the past three or four years causing development of lateral branching and more complex growth form.

H -- Heavily or closely hedged. Heavy use in past three or four years causing a very much "broomed" or "clubbed" appearance.

Density of sagebrush is taken at each tenth shrub using an angle gauge with a basal area factor equal to 40.

8.8.2.2.4 Method of Analysis

The null hypothesis to be tested are:

H_0: No difference exists in percent bitterbrush utilization between control and developmental sites.

H_0: No difference exists in percent sagebrush utilization between control and developmental sites.

The resolution for rejection of the null hypothesis will be at $\alpha = 0.05$.

Production and utilization of bitterbrush, in terms of lengths of current annual growth available to deer, are expressed as mean shoot length in the fall for each transect. Mean values are calculated using an unweighted analysis (the sample is considered to be the shrub, not the individual shoot). Similarly, mean values are calculated for the length of current annual growth remaining in spring. Utilization is then expressed as the percent of current annual growth consumed. Sampling efficiency (adjustments in number of shoots or shrubs to optimize field time) are made using a 3-level nested analysis of variance and an examination of the variance accounted for by each sample level. Testing for

yearly trends or for changes in patterns of deer forage utilization are approached similarly to procedures described in Section 8.8.2.1, Deer Pellet-Group Counts.

Results of sagebrush ocular estimates are analyzed using non-parametric procedures and will be compared to bitterbrush and pellet group data.

8.8.2.3 Migration Phenology

8.8.2.3.1 Scope

Deer road counts are used for estimates of the dates that deer arrive and leave winter range, for an index of regional deer abundance, and for estimates of age-class composition. The area over which data are gathered consists of the meadows and forests adjacent to County Road 5 from Rio Blanco to the White River, a distance of 41 miles.

8.8.2.3.2 Objectives

The primary objective of road counts is to monitor the pattern of deer distributions along the 41-mile length of road in order to detect displacements of deer adjacent to Tract C-b. If, for example, activities on Tract C-b caused deer to avoid the immediate vicinity, this should be manifested in counts of deer in meadows near the tract compared to meadow counts elsewhere. Secondary objectives of road counts are to obtain descriptive data on general levels of off-site deer abundance and age-class composition. These data are used in overall interpretations of monitoring results.

8.8.2.3.3 Sampling Design

Counts are made approximately four times each month from mid-September to late May. Counts are made during evenings from a vehicle traveling approximately 30 m.p.h. Direction of travel along the road is reversed on consecutive counts.

Deer are recorded for 1-mile intervals and according to feeding location (meadows, south-facing slopes, etc.). See Table 8.8-2 for example of the data form.

8.8.2.3.4 Method of Analysis

The null hypothesis to be tested is:

H_0: No difference exists between the number of deer observed between control and developmental sites.

The null hypothesis will be tested at the level of significance, $\alpha = 0.05$.

Evaluating possible displacements of deer have thus far been restricted to inspection of data displays. The results provide a graphic presentation of the seasonal and yearly patterns of deer along the 41-mile length of road. To date these patterns have been very consistent. Should an apparent displacement occur, the statistical method described in Section 8.8.2.1 would be used to test for significance of the observed decline in the deer numbers.

8.8.2.4 Road Kill

8.8.2.4.1 Scope

Deer road kill data are collected along the 41-mile length of road described in Section 8.8.2.3, above.

8.8.2.4.2 Objectives

The objective of monitoring road kills is to quantify the frequency and location of kills and to evalute the causal factors involved.

TABLE 8.8-2

Example Data Form: Piceance Creek Deer Study
Deer Count/Road Kill

Date __________
Weather __________

Mile Marker	Location	No. of Deer	* M	* N	* S	* E	* W	Comments
41	White River City							
40	Piceance Bridge							
39	Lower Canyon							
38	Piceance Canyon							
37	Yellow Creek							
36	Stinking Springs							
35	Old Bridge							
34	Little Hills Turnoff							

* M - Meadows

* N, S, E, W - Compass Directions

8.8.2.4.3 Sampling Design

Road kills are recorded for weekly intervals from mid-September to late May along the 41-mile length of road described previously (see Section 8.8.2.3).

8.8.2.4.4 Method of Analysis

The null hypothesis to be tested is:

H_0: No difference exists in road kills as a result of increased traffic destined for C-b Tract.

The null hypothesis will be tested at the level of significance, $\alpha = 0.05$.

At the present time road kill data have not been analyzed in any rigorous manner. Data on road kills are now approaching the point, however, where sample sizes are fairly large and amenable to statistical treatment. A multivariate statistical design is explained in Section 8.8.2.7, Interrelationships.

8.8.2.5 Natural Mortality

8.8.2.5.1 Scope

Data on natural mortality of deer (winter kill) are being gathered in ten lateral draw locations that are on or in the immediate vicinity of Tract C-b. The total area sampled is 174 acres.

8.8 Biology

8.8.2.5.2 Objectives

The objective of natural mortality studies is to document yearly trends, which aid interpretations of other monitoring data.

8.8.2.5.3 Sampling Design

Certain lateral draws on and near Tract C-b were identified during baseline studies as areas where many deer die during the winter. Counts of deer carcasses are made in ten of these areas each spring. Age and sex are recorded when possible, and each carcass is marked with a metal tag stamped with the current year. Presence of either the skull or pelvic girdle constitutes a carcass. Age is estimated by tooth wear.

8.8.2.5.4 Method of Analysis

The null hypothesis to be tested is:

H_0: No trend exists in number of deer carcasses found.

The null hypothesis will be tested at $\alpha = 0.05$ level of significance.

Data are merely tabulated as carcasses per draw and total carcasses per year. Trends can be evaluated using regression analysis. Differences among draws can be evaluated using analysis of variance or nonparametric tests.

8.8.2.6 Age-Class Composition

8.8.2.6.1 Scope

Estimating the age-class composition of the deer herd in the fall facilitates evaluating the magnitude of fawn mortality that occurred during spring and summer while deer were on summer range. Estimates taken in spring permit estimating the fawn mortality that occurred while deer were on winter range in the C-b Tract area.

8.8.2.6.2 Objectives

The main objective of the age-class study is to estimate fawn-adult ratios in fall and in spring.

8.8.2.6.3 Exerimental Design

Sampling locations will be restricted to the meadows of major drainages within five miles of Tract C-b. Counts will occur in November and in April. Observations will take place during times of high concentrations. The deer that could be clearly observed will be recorded as adults, fawns or bucks. No attempt will be made to recognize yearlings, and bucks (and the number of points on both antlers) will be recorded only when feasible.

8.8.2.6.4 Method of Analysis

The following hypothesis will be tested in this analysis.

H_0: No significant difference exists in fawn-to-adult ratio on a year-to-year basis.

The data will be analyzed using non-parametric statistics (log-likelihood G test). Since there are no controls being used for comparing age class composition and deer mortality studies, no significance level will be set for rejecting the null hypotheses. When sufficient data become available for year-to-year proportions to be established, the T-test for proportions will be used to test the null hypothesis at the $\alpha = 0.05$ level of significance. Data from this program are combined with data on the deer herd on and near Tract C-b. Interrelationships with other ecosystem elements will be evaluated through use of multiple time series techniques.

8.8.2.7 Interrelationships

8.8.2.7.1 Deer Pellet-Group and Browse Interrelationships

8.8.2.7.1.1 Scope

Interrelationships between pellet-group densities and three browse variables are examined on all available transects. The most recent annual report (1982) evaluated data from 19 transects. The additional 12 transects proposed will expand this sample size to 31 transects, all of which will be located within Tract boundaries.

8.8.2.7.1.2 Objectives

Objectives of examining interrelationships between pellet-group and browse data are: 1) to obtain correlations and thereby elucidate similarities between data sets that are separate measures of deer abundance, and 2) to explore possible ways of strengthening tests for detecting development-related responses in the local deer population.

8.8.2.7.1.3 Sampling Design

See Sections 8.8.2.1, Pellet-Group Counts and 8.8.2.2, Browse Production and Utilization.

8.8.2.7.1.4 Method of Analysis

The following null hypothesis will be tested:

H_0: No difference exists between control and developmental sites using a linear combination of pellet group densities and percent utilization of bitterbrush.

Past analyses have involved mainly simple correlations, multiple correlations, and comparisons of coefficients of variation. These analyses will be continued. As well, multivariate analysis of variance will be explored in the future to see if a linear combination of pellet and browse variables will increase the sensitivity of detecting differences between development and control sites.

8.8.2.7.2 Deer and Vegetation Interrelationships

Interrelationships between deer and vegetation studies will be restricted to the 12 transect locations proposed for the new developmental sites.

8.8.2.7.2.1 Objectives

The main objective of examining possible interrelations between deer and vegetation studies is to better understand the casual factors influencing deer distributions and numbers in the Tract C-b area.

8.8.2.7.2.2 Sampling Design

The proposed sampling design was developed to meet the independent objectives of both vegetation and deer studies as well as the objectives of the interrelationship component. Up to twelve transects will be arranged within a 200m zone surrounding shale disposal sites. Methods used for pellet-group counts, browse studies, and vegetation sampling are described in their respective sections.

8.8.2.7.2.3 Method of Analysis

The null hypothesis to be tested is:

H_0: No dependence of the response variable on the predictor variables exists.

The null hypothesis will be tested at the level of significance, $\alpha = 0.05$.

Multiple regression (MR) will be used for evaluating interrelationships among the biological variables available from deer and vegetation studies.

Two examples of response variables, along with a set of potentially important predicator variables, could be conceptualized as:

(1) Bitterbrush utilization: pellet-group densities + semi-shrub production + forb production + distance to shale disposal site...

(2) Utilization of western wheatgrass: number of cattle + deer pellet-group densities + production of western wheatgrass + aspect...

In the above two examples, bitterbrush utilization and utilization of western wheatgrass are response variables. Each would be analyzed using a set of potentially important predictor variables. Each response variable is viewed as being potentially influenced by all the following predictor variables.

8.8.2.7.3 Deer Road Kills and Causal Factors

8.8.2.7.3.1 Scope

Road kills and their possible causal factors will be examined over the road count route from Rio Blanco to the White River.

8.8.2.7.3.2 Objectives

The objective of the road kill interrelationship analysis is to attempt to single out the important causes responsible for influencing the number of road kills.

8.8.2.7.3.3 Sampling Design

See Section 8.8.2.4.3, Road Kills.

8.8.2.7.3.4 Method of Analysis

The following null hypothesis will be tested:

H_0: No dependence of the number of road-kill deer on the predictor variables exists.

The null hypothesis will be tested at a level of significance, $\alpha = 0.05$.

Multiple regression, MR, will be used to evaluate deer road kills and the possible predictors or causal factors involved. Much of the rationale for using MR was explained above in Section 8.8.2.7.2. Traffic volume, time of year, time of day, deer road count data, and perhaps several additional predictors will be used to see if two or more factors are working in concert to affect the number of road kills. It is likely, however, that at the present time the MR analysis will suffer because of small sample size. Yet, the analysis will be valuable if it only serves to suggest the most important predictors and facilitates gathering the kind of data that will be useful to analysis in the future.

8.8.3 Medium-Sized Mammals

8.8.3.1 Scope

Studies of medium-sized mammals will be restricted to lagomorphs: cottontails and jackrabbits. Currently plans are to continue studies along all deer pellet-group transects, and along the additional 12 transects proposed (see Section 8.8.2.1.

8.8.3.2 Objectives

Objectives of lagomorph studies are primarily to document trends in levels of abundance. Also, lagomorph data could prove useful in impact detection.

8.8.3.3 Sampling Design

Presence-absence data are gathered on lagomorphs by checking for cropping within 0.001 acre quadrats. The quadrats are nested within the 0.01 acre quadrats used for deer pellet-group counts.

8.8.3.4 Method of Analysis

Trend analysis is anticipated for lagomorph data (regression statistics) when sufficient data are available to be statistically significant. Nonparametric tests will likely be used to check observed declines in numbers due to impacts. Lagomorph data also may prove important to the plant-animal interrelationship analyses discussed in Section 8.8.2.7.

The null hypothesis to be tested is:

H_0: No difference exists in pellet-group counts between control and developmental sites. (The test is likely to be input only in the context of a multivariate model.)

The null hypothesis will be tested at a level of significance, $\alpha = 0.05$.

8.8.4 Small Mammals

8.8.4.1 Scope

Small mammal studies have been performed on Tract C-b in all major habitat types, but with emphasis placed on chained rangeland and pinyon-juniper woodland.

8.8.4.2 Objectives

The major objective of small mammal studies is to detect local impacts.

8.8.4.3 Sampling Design

Sampling designs have varied during baseline and monitoring programs. In recent years emphasis has been placed on improving the sensitivity of methods at detecting differences in abundance levels between areas, and in gaining a better understanding of the importance of microhabitat features to small mammal populations. A sampling design has now been developed that has proven to be sensitive to detecting small changes in the abundance of the more common species. The method is referred to as the moving-transect method.

Ten locations are chosen randomly, each in a different but contiguous square-mile section. Four transects of livetraps are positioned at each location the first day using a systematic random design; the first location of regularly spaced transects was a random choice. Transects are parallel, 10m apart, and consist of ten traps spaced at 10m intervals. Each set of four transects is moved ahead 10m each day for six days. Each location, therefore, receives a 240 trap-night effort (or n = 24, since each transect of ten traps represents one sample).

At all 240 transects (24 per location x 10 locations) measurements are obtained on eight characteristics that are considered to be important components of small mammal habitat. These are listed below along with the measurement scale used.

Habitat Features	Measurement Scale
Amount of deadfall (large limbs and stumps)	1-5
Amount of loose rock (rocks > 6 inches)	1-5
Amount of grass-forb cover	1-5
Cover by sagebrush	1-5
Cover by bitterbrush	1-5
Cover by conifer	1-5
Aspect: east facing	East
Aspect: west facing	West

Measurements are made by one individual. All measurements pertain to a $1000m^2$ area (the transect length times 5m to either side of the transect).

8.8.4.4 Method of Analysis

The following null hypothesis will be tested:

H_0: No difference exists in small mammal abundance between control and developmental sites.

The null hypothesis will be tested at a level of significance, $\alpha = 0.05$.

8.8.5 Avifauna

A wide variety of birds exists on Tract C-b and in the surrounding area. Avifauna will be monitored to determine potential effects of Tract activities and related habitat disturbance on relative abundance and species composition.

8.8.5.1 Songbird Relative Abundance and Species Composition

8.8.5.1.1 Scope

Songbirds will be monitored during their breeding season to determine effects of development on avifauna. It is anticipated that habitat disturbance and increased human activity may effect population densities and relative abundance of the more prominent species. Certain species may be more affected by man-made impacts that others.

8.8.5.1.2 Objectives

Objectives of the program are to evaluate effects of development activity on songbird densities, species abundance and diversity by comparing control to developmental transect observations.

8.8.5.1.3 Experimental Design

Species density, relative abundance and diversity will be determined by the Emlen strip transect method, adjusting observed numbers by procedures employed in the inventory/baseline program. Monitoring of the avifauna transects will occur in May during the peak of the breeding season. Four transects will be sampled: two in pinyon-juniper woodland and two in chained pinyon-juniper rangeland. Additional transects will be added in the new development sites along the new deer pellet transects. Control transects BH01 and BH04 are located in areas which will not be disturbed by oil shale development. The two developmental transects (transects BH02 and BH03) are located within each habitat where some disturbance from oil shale development is anticipated. All transects are 100-by-200 meters in size and are permanently marked with steel rebar stakes and flagging. This method provides data from which quantitive estimates of density of songbird-like species can be calculated. Such information can be used to determine if variations in bird populations at the developmental plots area are a result of oil shale development activities or are merely a response that could be attributed to other causes, either natural or man-made.

Data collected during the inventory/baseline phase of the C-b shale oil project constitute a strong justification for limiting the bulk of avian monitoring to the breeding season. Section V E 2b (Efficiency of General Data) of the Annual Summary and Trends Report indicates reasons why monitoring in the Piceance Basin during the winter and migration period would require extraordinary efforts and still would generally lead to data of questionable utility. Censuses will be conducted during periods of peak daily activities, generally within 3.5 hours of sunrise and sunset. To provide necessary census replication for statistical analysis, censuses will be conducted in triplicate at each of the transects.

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

8.8.5.1.4 Method of Analysis

The following hypotheses will be tested in this analysis.

H_0: No significant difference exists between relative abundance, population density, and species composition over time at a given plot.

H_0: No significant difference exists between relative abundance, species composition, and population density at control plots, vs. developmental plots in any given year.

The null hypothesis will be tested at the level of significance, $\alpha = 0.10$.

The population density estimates for species observed on strip transects will be determined by one of three methods, depending on the conspicuousness of the species to the observer, as described by Emlen (1971).

Since the validity of any of these methods varied for different species, professional judgement, based on experience with the conspicuousness of various species within different habitats during different seasons, was used in selecting the best density estimator. The Shannon-Weiner calculations (Pielou 1966) will be used to compute indices of species diversity, maximum diversity and equitability or relative diversity for each habitat sampled by strip transect procedures. Analysis of variance, T-test or U-test, total density value and time series modeling will also be used to analyze the data, as appropriate.

8.8.5.2 Upland Gamebirds - Mourning Dove Relative Abundance

8.8.5.2.1 Scope

Field observations during the baseline data accumulation program indicated that sage grouse and blue grouse populations are so sparse on and near the Tract that no reasonable monitoring program for them can be designed to determine changes over time. Therefore, a monitoring program for them is not warranted. The mourning dove is the only upland gamebird present in sufficient numbers to be monitorable.

8.8.5.2.2 Objectives

The objective is to monitor the mourning dove populations to determine if development of Tract C-b has affected their relative abundance.

8.8.5.2.3 Experimental Design

Methods and transects to be used are identical to those used for songbirds. Throughout the year gamebirds observed will be recorded on Wildlife Observation Reports.

8.8.5.2.4 Method of Analysis

The following hypotheses will be tested in this analysis.

H_0: No significant difference exists in mourning dove relative abundance over time.

H_0: No significant difference exists in mourning dove relative abundance at control plots and mourning dove relative abundance at development plots in any given year.

The null hypotheses will be tested at the level of significant, $\alpha = 0.10$.

The data will be analyzed in the identical manner described for relative abundance for the songbird-like population parameter.

8.8.5.3 Raptor Activity

8.8.5.3.1 Scope

Raptor activity is monitored on Tract C-b on a continuing basis because of the importance of raptors in the food chain, their apparent vulnerability to man's activities, their political value as threatened or endangered species, and their aesthetic appeal.

8.8.5.3.2 Objectives

The main objective of raptor monitoring is to detect changes in raptor utilization on or near Tract C-b.

8.8.5.3.3 Experimental Design

Trends in utilization of Tract C-b and immediately contiguous habitats by raptors will be established for each breeding season by determining the percent of known nest sites occupied by nesting pairs and comparing these data with data obtained during the baseline period and following years. Each year nest occupancy checks will be made annually during April for the early nesters (great horned owls, ravens, etc.), and again in June and for the later nesters (red-tailed hawks, American Kestrels, etc.). During the April and June checks, the relative abundance of winter and summer resident raptors on Tract and in the study area surrounding the Tract will be monitored. Throughout the year, all raptors observed in the Tract area will be recorded.

8.8.5.3.4 Methods of Analysis

Data analysis of nest occupancy will utilize professional judgement and possibly some non-parametric tests.

8.8.6 Aquatic Ecology

The variables of the aquatic program to be sampled are benthos and periphyton. Since aquatic ecosystems could be secondarily affected by mining and development on Tract, aquatic monitoring is essential. Benthos and periphyton are "indicators" of a significant change in stream characteristics downstream from oil shale development. Also, if a significant difference is noted, a systems-dependent study (fish shocking) may be initiated. Statistical comparisons to baseline data would show changes from baseline conditions and indicate, through correlation coefficients, the severity of the impact so that timely corrections of detrimental conditions could be made.

8.8.6.1 Benthos

8.8.6.1.1 Introduction and Scope

The benthic macroinvertebrate community is an important component of the stream ecosystem. These organisms process and convert organic material into animal tissue, which is thereby available to higher tropic levels such as insectivorous fishes. For some time, macroinvertebrates have been recognized as valuable indicators of water quality (Kolkowitz and Marsson, 1909); Hynes (1970); Cairns and Dickson (1973).

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

8.8.6.1.2 Objectives

The purpose of this investigation is to infer water quality and bioproductivity from macroinvertebrate taxa present. Data collected on benthos taxonomic composition, relative abundance, and diversity at all sampling stations permit the evaluation of effects of development activity on benthos as well as identification of potential impacts on other components of the aquatic system.

8.8.6.1.3 Experimental Design

Benthic macroinvertebrate sampling stations are located at three sites along Piceance Creek (Figure 8.8-2). These sites are listed as WP01 (Stewart Gulch near USGS Station WU07), WP02 (Middle Station), and WP03 (Hunter Creek near USGS Station WU61) and are described in Figure 8.8-2. Station WP01 was moved in 1977 from a baseline location of P-1 farther upstream to its current position as a control station above potential development impact.

A standard Surber sampler will be used to obtain three replicate benthic samples from each station at approximately one month intervals from May to October (6 sample periods). Each replicate is placed in a labeled container and preserved with 10% formalin in the field. The samples are shipped to the consultant for further processing and analysis.

8.8.6.1.4 Method of Analysis

The following hypotheses will be tested in this analysis.

H_0: No significant change exists in benthic communities over time.

H_0: No significant difference exists in benthic communities at control stations vs. developmental stations for baseline data, adjusting for the difference during baseline.

A statistical analysis of variance will be used to test for significant differences between control and developmental stations. A significance level of $\alpha = 0.10$ will be used.

FIGURE 8.8-2 BENTHIC MACROINVERTEBRATE AND PERIPHYTON SAMPLING STATIONS

By comparing recent seasonal trends to previous years, potential Project effects upon the benthic fauna of Piceance Creek are obtainable. To aid in this comparison, the following data are calculated for each sample station during each sample period:

1. Taxonomic identification
2. Density (organisms/m^2)
3. Relative abundance
4. Shannon-Weiner diversity index
5. Maximum diversity
6. Evenness
7. Analysis of variance

Density (and relative abundance) estimates derive directly from the counts of organisms in each Surber sample since the area of the sample is known.

The diversity index used is based on the Shannon-Weiner function from the field of information theory (Margalef (1967)); Lloyd and Gherlardi (1964); Pielou associated with benthos counts. Descriptions of these methods are found in Snedecor and Cochran (1967) and Elliott (1977). Duncan's new multiple range test is used in multiple comparisons (Ott (1977)).

8.8.6.2 Periphyton

8.8.6.2.1 Introduction and Scope

Sensitivity of periphyton to changes in their environment has been well documented (Cholnoky (1968), Lowe (1974), Whitton (1975), Patrick (1977)). Species composition and relative abundance of the total periphyton community and key periphyton species can provide good indicators of potential Project effects on aquatic systems. Not only are periphyton amenable to sampling techniques which provide a good quantitative data base for identifying changes quickly and

accurately, but they are also attached forms which cannot swim away from an adverse situation and return when conditions become more suitable for their existence. Many algal generation times are measured in hours or days rather than months or years. Thus, algae are very sensitive to changes in their environment and provide important information for evaluating the potential effects of Tract C-b development on Piceance Creek biota.

8.8.6.2.2 Objectives

The purpose of this investigation is to infer changes in water quality by examining algal bioproductivity. Data collected on periphyton species composition, relative abundance, diversity, and biomass at all sampling stations permit the evaluation of potential effects of development activity on periphyton communities as well as identification of potential impacts on other components of the aquatic system.

8.8.6.2.3 Experimental Design

The periphyton sampling stations located in Piceance Creek are identified on Figure 8.8-2. Periphyton are collected from artificial substrates (glass slides) at each station during six sampling periods (at approximately one-month intervals from May to October). The glass slides are incubated in the water for at least 29 days. Eight slides are collected from each station, placed in individual cytomailers and preserved with 4% formalin. Three of the nine slides are used for toxonomic identification and enumeration, three for biomass determinations, and two were extra slides in case any of the others became damaged. The cytomailers are sent to the consultant for analysis.

8.8.6.2.4 Method of Analysis

The following data are obtained:

1. Species identification
2. Total taxa by sample and station
3. Density (organisms/mm^2)
4. Relative abundance
5. Biomass (mg/cm^2) per sample
6. Shannon-Weiner diversity index
7. Maximum index
8. Evenness
9. Analysis of variance

These are straight forward techniques and are not described here.

The Shannon-Weiner index along with the actual number of species observed is the most useful measure of diversity (Hutchinson (1975)). Methods for calculating the Shannon-Weiner index, the maximum index, and the Evenness are provided in Section 8.8.6.1.4. The relative abundance of certain indicator species may disclose the potential impact of oil shale development on the periphyton community. In this analysis, the following hypotheses are tested:

H_0 = No significant change exists in the periphyton communities over time.

H_0 = No significant difference exists in the periphyton communities at the control station vs. the development stations from baseline data, recognizing the differences during baseline.

A significance level of $\alpha = 0.10$ will be used.

8.8 Biology

Analysis of variance is used to compare periphyton data collected at different stations. The data is log $_{10}$ transformed to reduce inequality of variance within samples. In many cases, especially with biological data, without a transformation there is too much within sample variability which leads to a loss of power to test various hypotheses (Elliott (1977)). Bartlett's test of inequality of variance is used to determine whether the transformation is successful. A factorial design (Snedecor and Cochran (1967)); Weber (1973) is used to detect any impact possible caused by oil shale development. Although the factorial analysis of variance is able to detect changes even though differences existed before any developmental impact, it is unable to separate two different impacts. Therefore, a significant difference is based on statistical analysis and professional judgement.

8.8.7 Terrestrial Vegetation Studies

The terrestrial vegetation studies portion of the Environmental Baseline Program was designed to describe the predevelopment environment within the C-b study area and to provide baseline data to be used in monitoring changes in the vegetation as a result of oil shale development. Baseline parameters were selected for their usefulness in describing the existing environment on Tract C-b. Development monitoring parameters were judged to be useful because of their measurability or relatively low natural variability, and/or sensitivity to expected environmental perturbations.

The vegetation studies portion of the monitoring program were first initiated in 1978 and were based on the best available projected development scheme at that time. Since that time, many changes have occurred in the Project, such that the current monitoring sites are not located in the most optimal places.

8.8 Biology

In order to assist in the evaluation of developmental impacts, the vegetation monitoring program will be expanded to include studies in the immediate vicinity of planned development areas. Vegetation monitoring in the sagebrush community types will be discontinued because of the limited area covered by these types and no impacts are expected to occur.

8.8.7.1 Vegetation Community Structure and Composition

8.8.7.1.1 Scope

The vegetation community structure and composition studies evaluate major changes in the make-up of the major plant communities on the Tract. Other vegetation monitoring programs provide a better means for statistically evaluating changes. The structural and compositional studies are better used for evaluating general vegetation trends. These studies are centered on four of the six intensive study sites established during 1974 and sampled on a rotational basis. Chained pinyon-juniper rangeland Plots 1 and 2 (BJ01, BJ11, BJ02, and BJ12) were sampled in 1978, pinyon-juniper woodland Plots 5 and 6 (BJ05, BJ15, BJ06, and BJ16) were sampled in 1979, and sagebrush Plots 3 and 4 (BJ03, BJ13, BJ04, and BJ14) were sampled in 1980. A yearly sequence for chained pinyon-juniper rangeland plots and pinyon-juniper woodland plots will be initiated beginning in 1984. These sites will be used as control sites for comparison and long term analysis.

The studies in the immediate vicinity of development areas will be conducted in a zone of influence surrounding the development areas (Zone 1). This zone will include areas which occur within 200 meters of the development area. Areas located outside the influence of development will be sampled for comparison. These will include areas of the Tract which are more than 800 meters away from development areas. The area between 200 meters and 800 meters will be a buffer zone which will not be sampled unless development related impacts are detected in

the development zone. If changes in the vegetation are occurring as a result of development, this zone-concept design will provide the best available method for detecting these changes. This design also allows for correlation of vegetation data with other studies which can be conducted in these zones. This is especially true for certain of the wildlife studies, such as the browse utilization studies and pellet-group transect studies. Structure and composition studies will be conducted in Zone 1 within the chained rangeland vegetation type. Sampling will be conducted during 1984 and 1985. After 1985, these areas will be sampled on the same rotational basis used for the chained rangeland type.

8.8.7.1.2 Objectives

The objective of the community structure and composition studies is to obtain long-term data from permanently located sampling quadrats to evaluate differences in species with respect to long-term trends. The productivity studies, discussed later, focus on monitoring a process (primary production); the structure and composition studies focus on performances of species within the major vegetation types.

8.8.7.1.3 Sampling Design

The community structure and composition studies are conducted at the four intensive study plots. Two are located in the pinyon-juniper woodland type and two in the chained rangeland type. At each location a grid of 25 one-square-meter quadrats has been established in a permanently fenced and in an adjoining open area (a grid in each for a total of 50 quadrats for each site).

Also, sampling in zone 1 will be conducted along permanently located transects (un-fenced) radiating outward from the areas of development. Four permanently located quadrats will be located along six transects for a total of 24 quadrats.

8.8 Biology

Shrubs are sampled along line-strip transects. The center posts marking the herb quadrats serve as end points of the transects, thus producing a total of 20 line-strips per grid. The herb quadrats are established on 10-meter centers. The line-strips are 10 meters long and 4 meters wide. Shrub cover estimates are obtained using a 10-meter intercept line located in the center of the line-strip. Density estimates are obtained by counting the number of individuals of each species within the line-strip. Individual shrubs are measured and recorded on the basis of height classes so that it is possible to obtain measures of population structure. The shrubs are separated into four height classes: Class I, 0.25 meters to 0.74 meters; Class II, 0.75 meters to 1.49 meters; Class III, 1.50 meters to 2.24 meters; Class IV, any shrubs equal to or greater than 2.25 meters. Shrubs smaller than 0.25 meters are considered woody species in the herbaceous layer.

Shrubs will be sampled within the zone surrounding the developmental area using the line-strip method. The location of each of the permanent quadrats will serve as the end point for a line-strip transect. These transects will be the same size and will be sampled in the same manner as shrub transects in the intensive study sites.

In the woodland plots, canopy cover for tree species is recorded along the same 10-meter intercept line used for estimating shrub cover. All of the trees within the area defined by the herb quadrat grid (40 meters by 40 meters) have been tagged and numbered. Changes in tree diameter are evaluated by repeated measurement of these trees. Trees are measured on a rotational basis (but due to slow growth, measurement will be a four year interval beginning the same year as the pinyon-juniper intensive study sites).

The parameters being monitored in this study include: Cover and frequency for herbaceous species; cover, frequency and density for shrubs; and diameter and canopy cover for tree species.

8.8.7.1.4 Method of Analysis

Data from the community structure and composition studies are mainly being evaluated through use of trend analysis. Total vegetation composition changes will be evaluated by examining trends in similarity indices.

Inherent differences between control and developmental plots of the same vegetation type makes direct comparison difficult; however, it is possible to evaluate trends through the use of similarity indices. If one of the paired plots is affected by development, its original similarity with the other plot should decrease. If neither of the plots are affected, then similarity between the plots should remain relatively constant. Similarity is calculated using the formula:

$$S.I. = \frac{2w}{a + b} \times 100$$

where: S.I. = Similarity Index

w = sum of the comparison parameter shared by the sites being compared

a = sum of the comparison parameter at one sampling location

b = sum of the comparison at the other sampling location

If a decrease in the similarity index of 10% between paired plots is detected, a change in sampling frequency will be initiated (i.e., the plots would be sampled again the following year, rather than waiting for the next three year rotational period). Should a trend of this degree in dissimilarity be established, an attempt will be made to identify the cause. Further analysis might include such items as a check on the micro-climates of each plot to see if they are appreciably different, a chemical analysis of the vegetation, a test of the air quality, or a chemical analysis of the soils.

8.8.7.2 Herbaceous Productivity and Utilization

Productivity of vegetation is intrinsically important in the operation of ecosystems on Tract C-b. The amount of production and availability of food are both of consequence for animal species within the system. Any significant interruption in production may well be manifested in changes throughout the ecological system. In terms of monitoring, herbaceous production is a more convenient parameter to measure than is vegetation community structure and composition and is a reflection of the total production in any of the communities on the Tract. By monitoring the herbaceous production it is possible to evaluate yearly and site-to-site differences in productivity. The scope of the herbaceous productivity and utilization studies include sampling on a Tract-wide basis through the use of range cages.

8.8.7.2.2 Objectives

The objectives of productivity and utilization studies are to provide the means for measuring trends of herbaceous production related to development activities, and to evaluate any changes in herbaceous utilization.

8.8.7.2.3 Sampling Design

Herbaceous production and utilization are being studied on a Tract-wide basis through the use of randomly located exclosures. These exclosures (range cages) are small in size and prevent grazing by large herbivores on slightly more than one square meter of ground. Individual placement of the range cages is determined by using random coordinates on the vegetation map of the Tract. These random sites are then located in the field. Once the sampling point is located, a second comparable nearby site is also located (usually within 5-10 meters of the first). The range cage is then randomly placed over one of the two sites. The "caged" quadrat is clipped later in the growing season in order to estimate

production. The other "non-caged" site is clipped in order to provide the data necessary for evaluating the degree to which the herbaceous vegetation is utilized by large herbivores.

Twenty-four pairs of sampling sites (range cages and open areas) will be placed throughout the Tract in the pinyon-juniper woodland community type and the chained pinyon-juniper rangeland community type. The quadrats are clipped at peak season (approximately mid-late July), and all the current year's growth is removed. Clipped samples are fractioned on the basis of species for western wheatgrass, cheatgrass and Indian ricegrass, and the basis of life form for other perennial grasses, other annual grasses, perennial forbs, annual forbs, and half shrubs. Caged and adjacent open areas are clipped at the same time. Clipped samples are returned to the lab, oven dried, and then weighed to the nearest milligram. These sampling sites will be located more than 800 meters from development areas and will be used as control sites for comparison purposes.

Production studies in the zone of influence (Zone 1) will be conducted along the permanently located transects. Four production/utilization sampling sites will be located along each transect. Total sample size for each zone will be 24 quadrats for production samples and 24 for utilization samples. These sampling sites will be positioned approximately at the ends and in the middle of each transect. The actual position of the production/utilization sites will vary from year to year, but will always be in the same relative position along the transect. All production/utilization studies will be conducted in the chained rangeland vegetation type. The clipping fractions for these studies will be the same as those used in other production/utilization studies, except that shrubs will also be clipped. These data will allow for a determination of total shrub production in the areas close to development. An evaluation of shrub production is included because of the importance of shrubs in the winter diet of mule deer.

8.8.7.2.4 Method of Analysis

Analysis of herbaceous production and utilization data is focused on four areas of comparison. The following hypotheses will be tested in this analysis:

H_0: No significant changes exist in:

1. Differences among vegetation types during a given growing season. (If these differences are not fairly consistent from year to year, and if they cannot be explained by natural yearly fluctuations, i.e., precipitation, then effects due to development or grazing would be suspected.)

2. Differences between fenced and open areas within a vegetation type during a given growing season. (This gives an indication as to whether or not development might be affecting utilization.)

3. Differences in production between the development zone and Tract-wide control areas.

4. Differences in utilization between the development zone and control areas.

Due to the high amount of natural variability in the vegetation on Tract - from year to year, between vegetation types, and even within the same vegetation type - it is difficult to state a strict action level and propose a certain action to be taken. As mentioned in Section 8.8.7.1.3, it is important to observe trends in vegetation data. For example, if an area chosen to show possible development affects (i.e., zone around development area) shows a trend toward decreasing herbaceous productivity, while the corresponding control area (or the Tract as a whole) show a trend toward increasing herbaceous productivity then an effect on herbaceous productivity due to development could be suspected.

In this case some of the actions mentioned in Section 8.8.7.1.3 would be initiated. In general, any action taken when significant differences exist in the comparisons mentioned will be professional judgement as to why there is a difference.

8.8.7.3 Micro-Climatic Studies

8.8.7.3.1 Scope

Studies on micro-climatic parameters on the C-b Tract provide data that are useful in assessing changes in vegetation production and structure, animal populations, or animal activity patterns, and may also be correlated with changes in functional components of the C-b ecosystem that may occur as a result of oil shale development.

8.8.7.3.2 Objectives

The objectives are to measure and evaluate time trends in climatic variables of surface and air temperatures, surface precipitation, and snow depth at specific locations within the various vegetative communities; and to provide data for ecosystem interrelationship studies.

8.8.7.3.3 Experimental Design

There are ten micro-climatic stations. The locations of these ten sites (see Station BC01 through BC13 on the jacket map) are the same baseline locations. Therefore, data from March 1975 through the present can be compared. Each station is monitored twice monthly for the following parameters: air and soil surface temperatures, precipitation, snow depth and moisture content.

MC Station Locations	Parameters Measured at each Station
BC01 Chained Pinyon-Juniper Rangeland, Vegetation Plot 1	Air Temperature
BC02 Chained Pinyon-Juniper Rangeland, Vegetation Plot 2	Soil Temperature
BC03 Plateau Sagebrush, Vegetation Plot 3	Surface
BC04 Valley Bottom Sagebrush, Vegetation Plot 4	Precipitation
BC05 Pinyon-Juniper Woodland, Vegetation Plot 5	Snow Depth and
BC06 Pinyon-Juniper Woodland, Vegetation Plot 6	Moisture Content
BC07 Chained Pinyon-Juniper Rangeland (Animal Trapping Transect)	
BC08 Bunchgrass Community, South-facing Slope	
BC09 Valley Bottom Sagebrush, Mouth of Sorghum Gulch	
BC13 Mixed Mountain Shrubland, North-facing Slope	

All temperature readings consist of maximum and minimum readings for two-week periods. Precipitation is measured only during the growing season, March through October. Therefore, precipitation data from meteorology station AB23 is utilized for winter month readings (November-February) for microclimate stations. Snow measurements are obtained approximately from November-February.

8.8.7.3.4 Method of Analysis

Methods of analysis include time series plots - contained in the Supplement(s) to the Development Monitoring (data) Reports - for precipitation, snow depth, and maximum and minimum temperatures, and correlations of micro-climatic data with plant and wildlife data. Section 8.6.3.1, Climatological Records, can also be consulted for additional tables, time series plots, and histograms.

8.8.8 Threatened and Endangered Species

Peregrine falcons have been reportedly sighted several miles to the south of Tract C-b. Bald eagles were observed several times on Tract C-b and in the general vicinity. These raptors have not been seen in any present or future developmental areas. No bald eagles nested or remained on the Tract for any great length of time. Since the area is not suitable for bald eagle habitat (marginal winter range) and the eagles were only occasional visitors, no further

action will be taken except for continued monitoring for their presence.

Sandhill cranes were observed several times east of the Tract and once on the aquifer test pad. The birds were seen along Piceance Creek and up West Stewart Creek. At this time, no further actions will be initiated with the exception of continued monitoring for their presence.

No threatened or endangered plants were found on or near Tract C-b. New plants are continually being added to the permanent herbarium on Tract. No threatened or endangered fish species are common to the streams in the vicinity of the Tract.

In conjunction with the numerous biological studies that will be conducted on and near Tract C-b during all parts of the year, observations confirmed by staff field biologists of any threatened or endangered species will be reported to the OSPO. Appropriate studies to determine significance of a sighting will then be initiated as determined jointly by CB and OSPO personnel.

8.8.9 Revegetation

8.8.9.1 Composition and Production

Revegetation monitoring will be conducted on sites which have undergone surface disturbance and on processed shale disposal sites. Monitoring techniques will assess the progress of re-established vegetation. Monitoring will be limited to revegetated areas of at least one acre in size.

Sampling of revegetated areas will be initiated during the third growing season. Past Tract C-b revegetation experiences have shown that weedy annuals, such as Russian thistle and Kochia, tend to dominate the sites for the first two years, and the desired perennial grasses, forbs and shrubs of the seed mixture start dominating the third year. Visual observations of the sites will be utilized until sampling is initiated.

8.8 Biology

All revegetated areas of adequate size for monitoring (>1.0 acre) will be fenced with four strand barbed wire fence in order to eliminate domestic livestock grazing.

8.8.9.1.1 Scope

Monitoring of revegetated areas will be similar to the monitoring of the terrestrial vegetation as discussed in Section 8.8.7. Each revegetated site will be sampled once during the growing season near the time of peak growth (about mid-July). Monitoring will include inventory measurements of species frequency, percent cover (herbaceous, shrub and tree), species diversity, and herbaceous biomass production.

8.8.9.1.2 Objectives

The objective of the revegetation program is not to recreate original plant communities (predisturbed vegetation) but rather to establish a vegetation type which is similar in structure and diversity, and is at least as productive as the pre-disturbance vegetation. The monitoring of revegetated areas, in conjuntion with baseline studies and ongoing monitoring of terrestial vegetation, will determine if that objective is met.

8.8.9.1.3 Sampling Design

Sampling for species frequency and percent cover will be conducted using a quadrat method. In each revegetated area a transect of at least 20 one-square-meter quadrats will be randomly located for sampling. The centers of each quadrat will be permanently marked with a stake so that the same area will be sampled each year. A visual estimation of cover will be made for individual species, rock, bare ground, litter, lichens and mosses.

As the shrub and tree seedlings become more established they will be sampled using the line-strip method of sampling described in Section 8.8.7.1.3.

The number of species per square meter will be used to determine the diversity of the vegetation.

A double sampling technique will be used in order to determine herbaceous production. At least 20 one-square-meter quadrats will be used per site. At the time of estimated peak standing crop an ocular estimate of the current years growth of the major vegetation fractions for each quadrat will be made. Additionally, at least five of the quadrats will be clipped and major vegetation fractions bagged. The major vegetation fractions are: wheatgrass, Indian ricegrass, wildrye grasses, other perennial grasses, perennial legumes, other perennial forbs, yellow sweet clover, cheat grass, annual grasses, annual forbs, and half shrubs. The clipped fractions will be returned to the lab, oven dried and weighed to the nearest 0.01 gram. A correlation between oven dry weights and ocular estimates will be made and ocular estimates will be adjusted accordingly.

8.8.9.1.4 Method of Analysis

Reference areas used for comparison of revegetated areas to undisturbed areas will be the control areas described in Section 8.8.7. The particular study plot to be used for comparison will be dependent on what particular vegetation type occupied the revegetated area prior to disturbance, i.e., if the revegetated area was in the chained pinyon-juniper vegetation type prior to disturbance, then the study plot in the chained vegetation type will be used for reference. In the case of herbaceous production range cages (caged quadrats only) will be used for comparison.

8.8 Biology

The evaluation of revegetation success is a one tailed test for statistical significance. The test is one tailed because interest is centered in knowing if the revegetation efforts have met or exceeded the standard (reference area). The evaluation requires a statistical test only when the revegetated means is less than or equal to the standard.

The hypotheses to be evaluated for revegetation success are:

H_o: Revegetated area is equal to or exceeds the reference area

H_a: Revegetated area is less than reference area

The calculated means for cover (%), diversity (species/m^2), production (lbs/acre) for both revegetated and reference areas are used.

In the case where the revegetated area is less than the reference area, a t-test comparison will be used to evaluate the revegetation success. The form of the equation is:

$$t_e = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

(Cochran and Cox, 1957)

where:

t_e = calculated estimate of t

$\overline{X}$ = mean for revegetated and reference area

S_2 = variance of mean

n = number of samples

8.8 Biology

The t-test equation calculates an estimated t value (t_e). The estimated value is compared to a t-table value (one tail) to evaluate revegetation success. If t_e is less than or equal to the t table value revegetation success is confirmed (H_0 is accepted). The null hypothesis will be tested at the $\alpha = 0.10$ level of significance.

8.8.9.2 Revegetation Demonstration Plots

There are presently two revegetation demonstration plots which have been constructed at the C-b Tract. One plot is for demonstrating revegetation of raw shale disposal embankments, the other plot is for demonstrating revegetation of spent shale disposal embankments. Prior to construction of any future demonstration plots, the appropriate regulatory agencies will be notified of construction, methodology and sampling specifics.

8.8.9.2.1 Scope

The main emphasis of the demonstration program is to evaluate the potential for successful revegetation of spent shale disposal embankments. The demonstration plot monitoring program will evaluate revegetation success of different amendments and combinations of amendments, which are incorporated into the different treatments at each plot.

Vegetation sampling will be conducted on each individual treatment which comprise the respective demonstration plots, sampling will be completed once each growing season near the time of peak growth. Sampling will include inventory measurements of species frequency, percent cover, species diversity, and herbaceous biomass production.

8.8.9.2.2 Objectives

The objective of the revegetation demonstration plot monitoring program is to determine the most efficient and successful revegetation methodology which can be implemented at the C-b Tract prior to large scale spent shale disposal. The evaluation and comparisons of the different treatments and combination of treatments, which comprise the demonstration plots, will assist in meeting this objective. The revegetation monitoring studies discussed in Section 8.8.9.1 will determine if the objective has been met.

8.8.9.2.3 Sampling Design

The sampling design for each plot will vary somewhat depending on the size of the plot and the individual treatments which the plot is comprised of. Basically the sampling for species cover, diversity, and production will be accomplished using randomly located quadrats. The size of the quadrats will be 0.10 m^2 rather than 1.0 m^2 because of the small scale size of the demonstration plots. Where possible 20 quadrats will be sampled per treatment. A visual estimation of cover will be made for individual species. The number of species per square meter will be used to determine diversity. The double sampling technique discussed previously will be used to determine productivity.

8.8.9.2.4 Method of Analysis

The method of analysis will mostly be determined by the numbers and types of different treatments incorporated into the respective demonstration plot. The statistical test which will be used to evaluate the possible differences between the treatments of each plot will be an analysis of variance (one-way, two-way, or possible three-way depending on the combination of ammendments which comprise the individual treatments). The respective hypothesis will be tested at the $\alpha = 0.10$ level of significance.

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

8.8.10 Systems Dependent Monitoring

Systems dependent programs occur only if "triggered" by indicator variables above the selected threshold level or if station requirements change. Programs which may be triggered include:

1) Aquatic Ecology - fish shocking if significant differences occurred in water quality, periphyton or benthos samples.

2) Sublethal Biochemical Studies - plant sample analysis for accumulation of pollutants in plant tissue if significant differences occurred in herb production, composition or general condition studies.

3) Soil Plant Elemental Analysis - soil and plant sampling for toxic elements if significant trends towards toxic levels are noted. These samples would be compared to a baseline analysis conducted in 1978 and other samples taken from the irrigation area, as well as samples from similar outlying control sites taken at the same time.

8.8.11 Special Projects

Special projects as defined here are those projects, or monitoring programs, which are implemented on an as-needed-basis. They are not considered a part of the permanent, ongoing monitoring plan. Therefore, the specific monitoring programs for these special projects will not be contained in this Plan. When the need arises to implement a special project, a monitoring program will be submitted for consideration and approval at least one year prior to implementing the program.

8.0 DEVELOPMENT MONITORING PLAN

8.8 Biology

It would be difficult at best to list all of the projects which could be encountered at CB during the life of the Project. Some projects which could be implemented and would be contained in this section are:

1) Wildlife Mitigation Projects
2) Excess Mine Water Disposal - Land Application System
3) Possible impact to wildlife and vegetation from air emissions (triggered if emission concentrations exceed allowable limits)
4) Leachate Studies

The monitoring programs for these, and other possible projects, will be patterned after and be consistent with the other programs of this plan.

8.0 DEVELOPMENT MONITORING PLAN

8.9 Items of Historic, Pre-historic or Scientific Interest

<u>TABLE OF CONTENTS</u>

Page

8.0 DEVELOPMENT MONITORING PLAN

8.9 Items of Historic, Pre-historic or Scientific Interest

8.9.1 Objectives and Scope

The objectives are to establish and maintain a program for continuing observation for items of historic, prehistoric, or scientific value during construction and Tract operations as required by Section 6 of the Oil Shale Lease Environmental Stipulations.

Reference is hereby made to the baseline program as discussed in Section 2.7, Cultural Resources, and to the Cultural Resources Control Plan as discussed in Section 6.13.

8.9.2 Planned Actions

The on-Tract Environmental Manager shall inspect all activities which might cause a disturbance of the land surface as often as is necessary to prevent disturbance or destruction of items of historic, prehistoric or scientific interest. Should such an item or items be uncovered, all activities causing further disturbance shall be halted and a report made to the Vice-President, Regulatory Affairs, who shall forward such report to the OSPO. When a question exists as to whether or not an object is of historic, prehistoric, or scientific interest or is an object of antiquity, activity shall be halted and an archaeological specialist will determine its significance and a report made to the OSPO for a final determination.

Development of the processed shale pile will be closely monitored, such that, if at all practicable, artifact sites 5RB136 and 5RB146 will not be covered. See Figure 6.5-1.

New employees will be briefed on Lease Environmental Stipulations, ecological parameters to be studied, the significance of monitoring areas, and the nature of materials of historic or scientific values likely to be found in the area.

8.0 DEVELOPMENT MONITORING PLAN

8.10 Health and Safety

TABLE OF CONTENTS

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.10 Health and Safety

Health and safety monitoring activities commenced with development activities in 1978. Additional monitoring programs will be designed and implemented as Project development continues and expands. There are three general types of monitoring activities: the monitoring of personnel, the work place, and events (e.g., accidents). Data gathered from monitoring is used to conduct and verify the effectiveness of many of the health and safety programs identified in Section 6.15.

8.10.1 Occupational Medicine

The purpose of the monitoring component of the occupational medicine program is to collect data on personnel that can be used in studies that correlate quantitive data of work place exposures with any change in employee health. The examinations required to obtain information on health are also used to determine whether an employee is physically able to perform the job and can properly wear the personal protective equipment that is required for some jobs.

Pre-Placement Examination and Medical History - The pre-placement physical examination covers blood chemistry (CBC), vision, spirometry, audiometry, chest x-ray, EKG (over age 40), urinalysis, pulmonary function, height, weight, and blood pressure. The data on medical and occupational history that are important to epidemiologic studies will also be gathered.

Annual Screening and Periodic Exams - Periodic examinations will be conducted to detect, as early as possible, any adverse health effects. The frequency of the examinations will depend on the age of the employee: under 35 -- every three years, 35 to 55 -- every two years, and over 55 annually. Those employees with special health conditions or abnormalities will be examined as often as the medical director determines necessary.

8.0 DEVELOPMENT MONITORING PLAN

8.10 Health and Safety

Morbidity and Mortality Records - All absences of employees for personal health reasons will be recorded (with diagnosis if possible) and stored in the occupational health computer data base for use in any epidemiological studies.

Worker Registry - CB is reviewing various methods of tracking former employees to obtain mortality information. Individual shale developers are addressing this need; and, in an effort to develop a coordinated program, the American Petroleum Institute (API) has held public meetings and explored registry concepts with state, national, and local health officials. In addition, the SFC will condition any funding support on the develoment of a registry. CB will coordinate with federal and state agencies, other shale oil developers, the API, and other interested parties in the development of a worker registry.

The objective of the worker health registry is to provide credible and verifiable medical data in sufficient volume and on a sufficient number of workers that any trend toward health disorder is recognizable at an early date. Initially the registry will be limited to the acquisition, long-term storage and verification of data by CB, but will ultimately be available for studies in epidemiology.

The data base will be designed to protect the privacy of the company and individual employees while also providing the capability to evaluate current employee morbidity and to track individuals who leave the employ of CB.

8.10.2 Gases

The threshold limit value (TLV) adopted by 1973 American Conference of Industrial Hygienists must not be exceeded by any gases or air contaminants. As defined by MSHA and OSHA, the TLV represents the maximum allowable concentration of gas or vapor that a human should be exposed to in an eight-hour day.

Carbon monoxide and methane monitors will be placed throughout the mine. These continuous monitors will be equipped with audible alarms and will be interconnected with the control room. Additional measures will be implemented at

the beginning of the mine development to ensure that any potential mine gases detected are adequately controlled.

Working areas in the mine and processing plant will be sampled automatically and manually on a regular basis to determine the quality of the atmosphere. Reporting frequency will be weekly. Employees will be provided with respiratory protective devices as necessary.

Examinations of working places will be made using approved detection equipment. Air velocities for such examinations will be based on readings taken from hand-held anemometers. Examinations for toxic gases will be made using tube detectors of the Draeger Multi-Tester type. Vacuum container samples will be taken for laboratory analysis as necessary. Daily air samples will be taken at the main air exhaust for the mine and at selected random locations for analysis by gas chromatograph.

8.10.3 Hazard Examination

Each surface and underground working place will be examined at least once each shift for conditions which could affect health or safety. This examination will include (but not be limited to) roof and ground conditions, ventilation, explosives, water hazards, electrical hazards, fire hazards, process hazards, equipment and travel ways. See Table 8.10-1 for a summary of potential work place hazards. Any hazards noted will be promptly corrected. Records of these examinations will be kept for one year.

Individual miners will examine and test the back, face, and rib of their working places at the beginning of the shift and frequently during the shift. Supervisors will examine ground conditions daily to ensure compliance with proper ground control measures.

In addition, all areas of the mine and processing facility will be inspected frequently, (no less than once each week) by an inspector of the Health/Safety/Security Department. A summary of worker classifications to be

TABLE 8.10-1

Potential CB Work Place Hazards

Potential Hazards	Source	Mitigating Measures
Dust	Mining activities such as blasting, mucking, scaling, crushing and hauling	Dust control programs which include watering, application of dust palliatives, work practice controls, and use of personal protective equipment
Noise	Blasting, haulage equipment operation, fans, pumps, alarms, drills	Specifying noise controls on equipment where feasible, administrative controls, personal protective equipment if needed
Organic/Inorganic Vapors	Above- and below-ground retorting and oil processing, maintenance work using solvents, laboratory tests	Engineering controls on process operations, adequate ventilation for maintenance and laboratory tests
Metal Fumes	Welding operation	Proper ventilation
Radiation (Radon Daughters)	All underground and surface operations involving shale rock	Monitoring and ventilation
Microwave Radiation	Microwave transmissions and microwave ovens	Monitor and control sources
Shale Oil	Liquid oil	Engineering, work practice controls, personal protective equipment
Diesel Exhaust	Diesel equipment	Emission controls, proper ventilation

subjected to work place monitoring and components monitored as shown in Table 8.10-2.

8.10.4 Accident Frequency Monitoring

Reportable accidents (the number) will continue to be reported to the OSPO in the data reports and incident rates (IR) will be calculated and reported as follows:

$$IR = \frac{\text{No. of Reportable Accidents} \times 200{,}000}{\text{Hours of Employee Exposure}}$$

8.10.5 Security

The security force will monitor surface work areas, as well as security areas (e.g., explosive storage area) to identify unsafe conditions. In addition, security infractions, such as crimes, unexplained fires, and gross negligence will be documented in monthly reports to facilitate control measures.

TABLE 8.10-2

Work Place Monitoring

Job Task	Work Place Montoring	Components
Underground Mining	yes	Dust, H_2S, SO_2, CO, CO_2, Arsenic, Noise, NO_x, Hydrocarbons, PNA, Formaldehyde, Radiation
Equipment Operators	yes	Dust, H_2S, CO, CO_2, Arsenic, Noise, NO_x, Hydrocarbons, PNA, Formaldehyde, Radiation
Process Operators	yes	Dust, H_2S, CO, CO_2, Arsenic, Noise, NO_x, Hydrocarbons, PNA, Formaldehyde, Radiation
Maintenance Personnel	yes	Dust, H_2S, CO, CO_2, Arsenic, Noise, NO_x, Hydrocarbons, PNA, Formaldehyde, Radiation, Welding Fumes (when appropriate)
Office Personnel	yes	Illumination, CO, Microwave Radiation, Ventilation
Laboratory Personnel	yes	Organic and Inorganic Chemicals, Illumination, Ventilation, Microwave Radiation

8.0 DEVELOPMENT MONITORING PLAN

8.11 Subsidence

TABLE OF CONTENTS

FIGURES

8.0 DEVELOPMENT MONITORING PLAN

8.11 Subsidence

8.11.1 Introduction

The subsidence monitoring program is designed to provide information and a record of the behavior of the ground surface and rock adjacent to the underground excavations in reaction to the advancing mine workings. This information is needed to formulate guidelines for future mining and development of the Tract as well as to provide safe operating conditions. This monitoring program is designed to:

1) Provide the capability of observing unusual situations during mining and retorting so that remedial measures can be instituted; and

2) To formulate guidelines for future in-situ mining and retorting efforts for development of the Tract.

Specific objectives of the program are to measure changes in the overburden and surface due to underground subsidence. The magnitude and rate of change, if measurable will help evaluate the potential effects on surface and underground facilities and develop criteria in predicted subsidence effects, if any.

The surface monitoring program consists of:

1) Leveling techniques for detection of vertical displacements; and

2) Distance and angle measurements for measuring horizontal and vertical displacements.

The underground monitoring program consists of the mine survey network and resurvey to determine changes in vertical and horizontal distances at regular intervals.

The specific schedules for mining and subsidence monitoring are given in Figure 8.11-1.

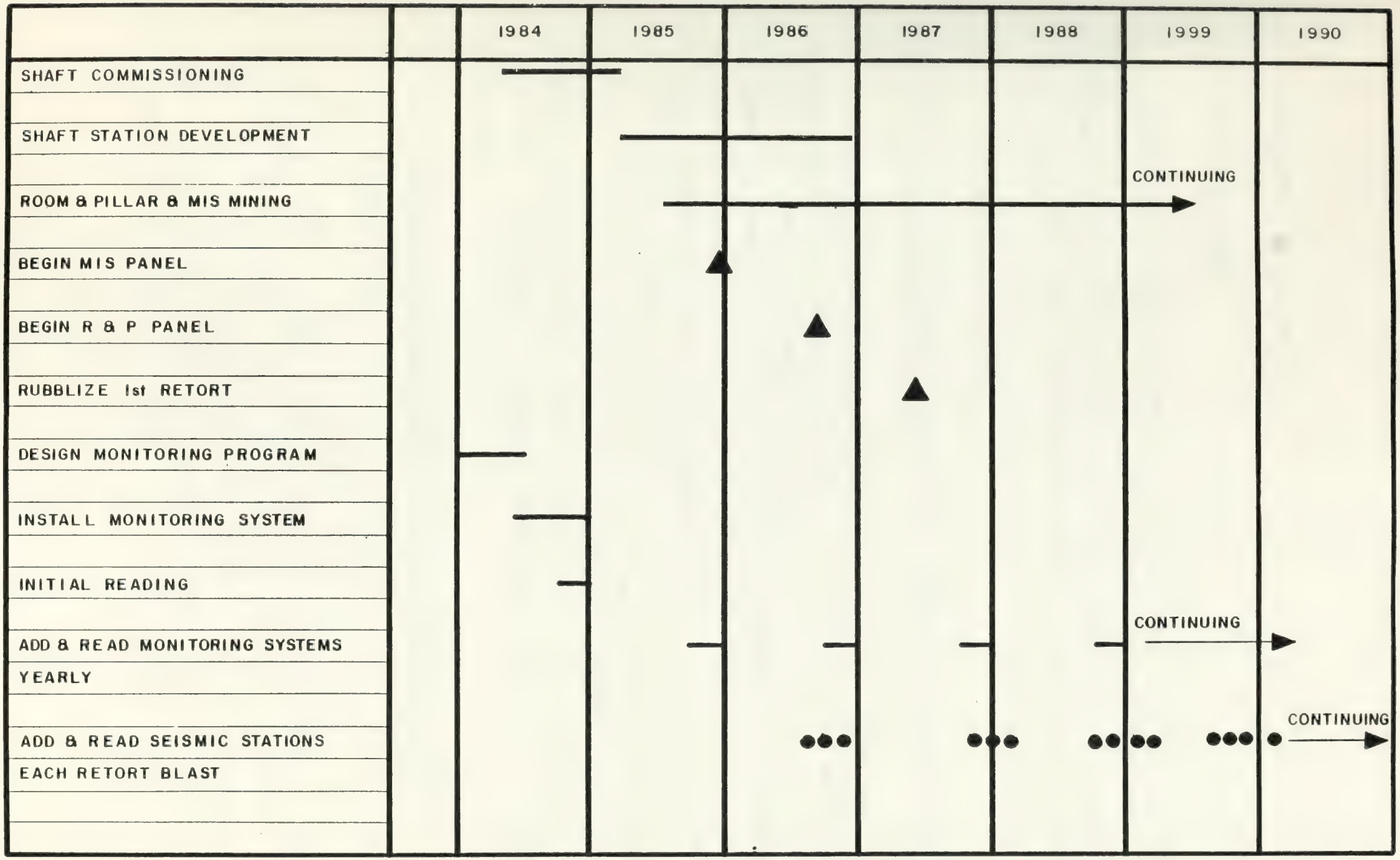


FIGURE 8.11-1
SCHEDULE OF MINING
ACTIVITES & SUBSIDENCE MONITORING

8.0 DEVELOPMENT MONITORING PLAN

8.11 Subsidence

Controlled subsidence following future pillar recovery offers considerable improvement of the mining-interval resource. Such a recovery plan and corresponding MIS redesign would not be initiated without complete knowledge of the effects of subsidence on the surface and aquifers above the mining zone.

8.11.2 Surface Monitoring Effort

8.11.2.1 Leveling Techniques, Equipment and Procedures for Vertical Displacement

The leveling techniques for measuring vertical displacements use a network of gridpoints over the surface area. Plant pillar and processed shale deposition areas will be specifically monitored for subsidence specifically monitored for subsidence as these areas are sensitive to ground movement. No subsidence is expected in these areas as they are located over nonsubsiding sections in the early development of the mine. The equipment used in the level survey consists of a self-leveling engineer level, optical micrometer and invar staves. Normal differential-leveling surveying techniques will be used to minimize errors. Permanent, standard level monuments will be used to alleviate surface effect due to moisture and temperature. Installation will occur after major surface construction. The expected accuracy of single measurements is on the order of 0.0005 foot.

8.11.2.2 Distance and Angle Measurements for Horizontal and Vertical Displacement

The distance and angle measurements for horizontal and vertical displacements will be measured with an electronic distance measuring device from selected "base" stations. Angles are to be measured with a theodolite (one-second accuracy) from selected "base" stations. Adequate primary, secondary, and tertiary "base" controls will be established to determine horizontal changes between level stations. Primary control stations utilize

present established section corners and Tract boundary locations, control elevation established at existing locations. An electric distance-measurement device and accessories will be used to measure distances. A theodolite (one-second accuracy) will be used for angular measurements. A primary triangulation network will be established on stable ground and maintained for the project life.

8.11.3 Underground Monitoring Effort

The mine surveying network will be utilized to determine vertical and horizontal displacements on all mining levels. A re-survey of the underground survey network will be undertaken at yearly intervals as shown in Figure 8.11-1, and changes in vertical and horizontal distances will be tabulated.

8.11.4 Specific Monitoring in the Shaft Pillar Areas

Level lines and tiltmeters will be installed as appropriate to shaft pillar and plant site designs. Appropriate measurements are those needed to allow operating equipment to perform in a satisfactory way.

8.11.5 Surface Vibration Measurements

At least three continuous-reading accelerometer stations will be established at widely spaced intervals at surface. Accelerometers will be mounted on concrete pads coupled to bedrock.

Data for accelerometers will provide a quantified assessment of the magnitude and duration of the rubblization blast-induced vibrations.

The monitoring network will be established before the initial rubblization blast as shown in Figure 8.11-1.

8.0 DEVELOPMENT MONITORING PLAN

8.12 Ecosystem Interrelationships

TABLE OF CONTENTS

LIST OF FIGURES

8.0 DEVELOPMENT MONITORING PLAN

8.12 Ecosystem Interrelationships

8.12.1 Introduction

An ecosystem is a collection of plants and animals (biotic components) interacting with one another and the non-living (abiotic) components of a common environment. The driving variables of an ecosystem are usually abiotic phenomena, such as precipitation and insolation, though influences resulting from human disturbance can also act as driving variables. Ecosystem interrelationships are relationships between two or more biotic and/or abiotic components of the system.

Studying the fluctuation of identified key relationships within a system can provide insight on how disturbances resulting from oil shale development are directly or indirectly affecting the ecosystem, i.e., cause and effect relationships. Disturbances caused by oil shale development could affect components of the ecosystem beyond the initial entry of a disturbance into the system, i.e., synergistic effects. The information gained from study of interrelationships can be used to guide the development of a continually more efficient and effective monitoring program.

During the Baseline Monitoring Period, an effects matrix was developed containing 112 effect receptors and 97 effect generators (Figure 5-7, CB Final Environmental Baseline Report, Vol. 5, System Interrelationships). These receptors and generators were ecosystem processes and components and environmental perturbations associated with oil shale development. Fifty-four candidate interrelationships were identified from this matrix for qualitative screening, and successful candidate relationships were subsequently subjected to quantitative study. As further data are accumulated, previously identified interrelationships will be investigated in greater detail, and new ecosystem interrelationships will be identified for analyses.

8.0 DEVELOPMENT MONITORING PLAN

8.12 Ecosystem Interrelationships

8.12.2 Objectives

The objectives of investigating ecosystem interrelationships are:

1) To determine the potential impact of environmental perturbations resulting from development activity;

2) To quantify relations between various biotic and abiotic components of an ecosystem;

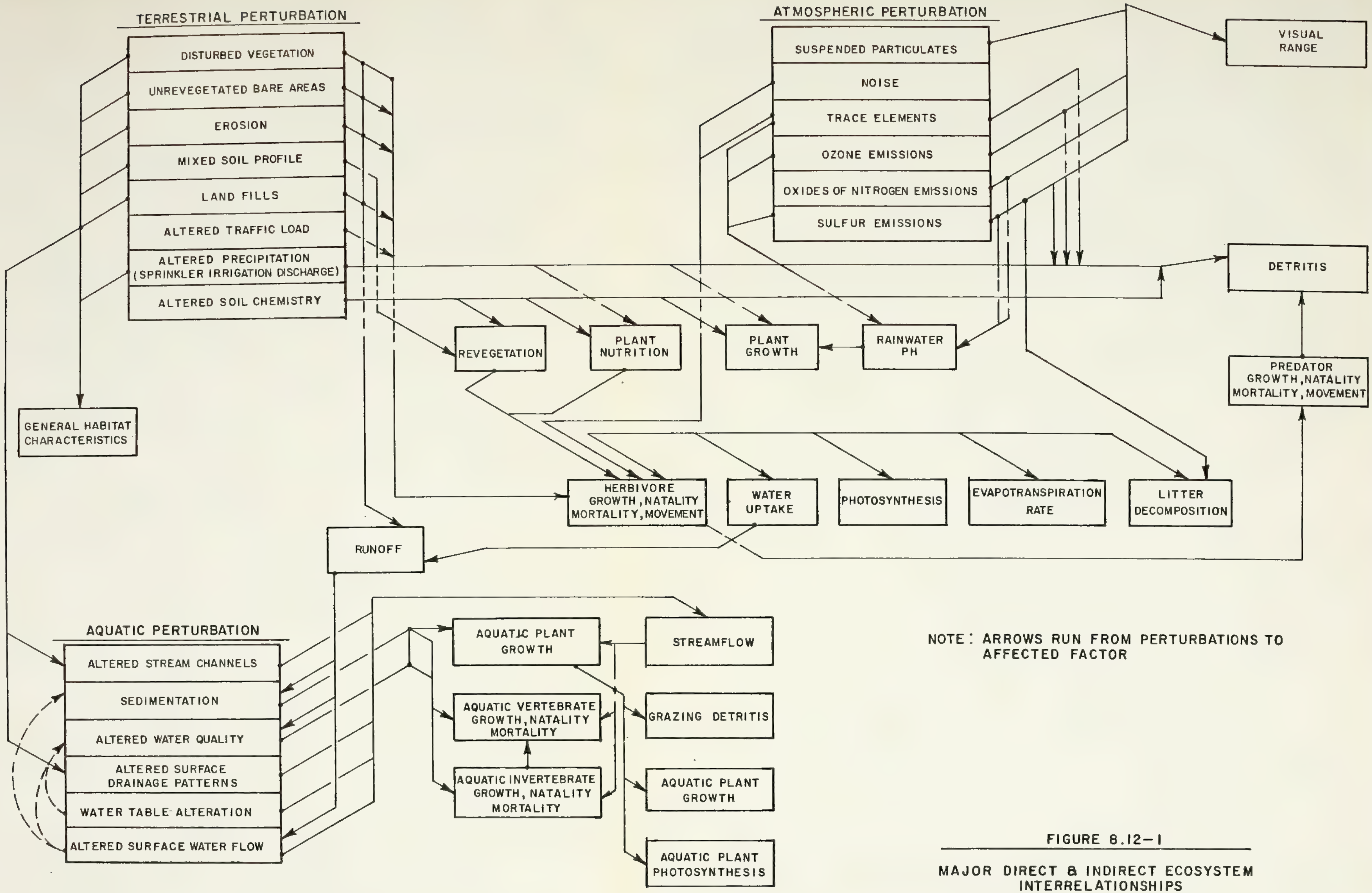
3) To identify possible ecosystem interrelationships that may exhibit greater sensitivity and earlier response to perturbations than monitored indicator variables;

4) To obtain preliminary information on ecosystem resiliency to natural or man-induced perturbations; and

5) To use information gained to improve the effectiveness and efficiency of the monitoring program through identification of improved indicator variables or reduction in non-productive monitoring elements, or both.

8.12.3 Experimental Design

Figure 8.12-1 is a flow chart of major direct and indirect ecosystem interrelationships. This flow chart includes only perturbations which may be created from oil shale development, though commercial development at Tract C-b will not necessarily result in every perturbation shown. This flow chart tracks the effect of a perturbation from its point of entry into the system. Only those effects of particular concern are shown for simplicity.



NOTE: ARROWS RUN FROM PERTURBATIONS TO AFFECTED FACTOR

FIGURE 8.12-1

MAJOR DIRECT & INDIRECT ECOSYSTEM INTERRELATIONSHIPS

8.12 Ecosystem Interrelationships

Disposal of surplus mine water exemplifies use of the flow chart. After treatment, the mine water could be disposed of in three ways:

1) released from holding ponds to Piceance Creek;

2) the sprinkler irrigation system; and

3) reinjection into the deep aquifer.

Using item 1 as an example, the point of entry into the system occurs at the boxes labeled "Altered Surface Water Flow," and "Altered Water Quality." The perturbation progresses through the system as the arrows indicate. If item 2 is used, the perturbation enters into the system at the box labeled, "Altered Precipitation (Sprinkler Irrigation Discharge)." Item 3 would initially affect the water table level and quality.

Figure 8.12-1 depicts the major interrelationships between ecosystem components of a conceptual model. To attempt to either study or program (for computer) such a model in its entirety is well beyond the intended objectives, scope, and requirements of the Lease. Instead, candidate subsets of interrelationships between components of the ecosystem most likely impacted by oil shale development are obtained by:

1) professional judgments of the Lessee, consultants, and the OSPO;
2) relevant previously developed ecosystem models and/or their submodels;
3) monitoring and analysis results obtained to date, using the criteria established for indicator variables of reliability, observability and measurability.

When an ecosystem interrelationship passes this screening process, hypotheses are formed which can be subjected to statistical analyses to determine existence and strength of relationship.

8.12 Ecosystem Interrelationships

Ecosystem interrelationships currently being analyzed include:

1) the relationship between indicator variables of deer density, browse production, percent browse utilization, hedging, and deer pellet-group densities;

2) the relationship between snow depth and deer road kill; and

3) the relationship between vegetative production and composition and amount of surface water received, both as rainfall and from sprinkling excess mine water in designated areas.

In addition, analyses of deer road kill vs. deer road count and/or vehicle count will be resumed when Tract development significantly increases traffic load.

Candidate interrelationships for possible future examination include the relationships between:

1) water quality and benthos and periphyton compositions, densities, and diversities, and/or vertebrate composition, density and diversity;

2) stream flow and components listed in candidate interrelationship No. 1;

3) the relationship between streamflow and sedimentation;

4) concentrations of boron and fluoride in water and concentrations in plants utilizing this water;

5) water table level and vegetative composition and productivity;

6) surface water flows and water levels in the alluvium and groundwater;

8.12 Ecosystem Interrelationships

7) salt level in mine water disposed via sprinkling system and concentration of salts in soil, vegetation, and animals consuming vegetation;

8) pH of rainwater received on-Tract and at key off-Tract stations and concentrations of nitrous and sulfurous gases coupled with meteorological constituents;

9) visibility, concentrations of gaseous and/or particulate constituents and meteorological parameters;

10) gaseous emission levels and plant growth;

11) trace element levels in atmosphere and plant and animal growth;

12) particulate concentration and solar radiation level;

13) various population dynamics of small mammals and birds and climatic variables and/or vegetation condition;

14) evapotranspiration rate and irrigated or natural soil moisture and/or vegetation biomass;

15) livestock grazing and vegetative production, utilization, nutrition, and/or composition; and

16) soil chemistry and vegetative growth and reproduction.

This list may be expanded and the relationships defined with greater detail as more continue to be accumulated.

8.0 DEVELOPMENT MONITORING PLAN

8.13 Process Monitoring

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 DEVELOPMENT MONITORING PLAN

8.13 Process Monitoring

8.13.1 Normal Process Monitoring

Monitoring will be conducted by the operations group for the purpose of controlling production and quality control. Table 8.13-1 describes the monitoring programs for the MIS, AGR, OUG and utility sections. This table identifies the general monitoring location, the process stream, type of sample, frequency of sampling, and type of analysis. Table 8.13-2 contains nomenclature used on Table 8.13-1.

Those monitoring plans, procedures and results related to proprietary elements of the process, royalties, resource recovery, and economics will be Project CONFIDENTIAL.

8.13.2 Monitoring of Unregulated Pollutants

The establishment of a monitoring program for unregulated pollutants requires that a screening program be implemented to identify pollutant groups or pollutants that may be present. The screening program should be designed to identify those chemical species eminating from the process that are present in sufficient quantities to warrant concern for health, safety, and the environment.

A chemical compound is generally considered to be a pollutant only when the concentration becomes large enough to produce unfavorable environmental impacts. A scan of liquid, gaseous, or solid samples taken from the process at the most sensitive detection levels available would likely show the presence of many of these pollutants. However, a liquid, gaseous, or solid sample drawn from a nominal ambient source anywhere would likely show the presence of many pollutants also considered to be undesirable. The key point in such analyses is the

TABLE 8.13-1
Process Monitoring*

Location	Stream	Type of Sample	Frequency	Analysis
Offgas Line ahead of Product Handling	O_2 and Light Gas Stream	Bag	As needed for instru. calibration	Gas Chromatograph: O_2, HC, Sulfur, NH_3, CO_2, CO, HCN.
Oil/Water Line near Bulkhead	Oil/Water from Bulkhead	Bottle (1 qt)	As needed	Density, BS&W, % water to calibrate in place analyzers, check demulsifier operation.
Offgas ahead of Contact Condensers	Combined Offgas Stream from MIS Retorts	Evacuated Bomb	1 per shift	Gas Chromatograph: Hydrocarbons, Sulfur, NH_3, CO, CO_2, HCN, O_2.
Bulkhead Oil Line between Underground Storage and Surface	Bulkhead Oil to Surface	Bottle (1 qt)	1 per shift	BS&W, Gravity, RVP.
Offgas Compressor Outlet	Contact Condenser Overhead Gas (Compressor Outlet)	Evacuated Bomb	1 per shift	Gas Chromatograph: Hydrocarbons, Sulfur, NH_3, CO_2, CO, HCN, O_2, H_2O.
Line between Stripper and Contact Condenser	Stripped Water to Contact Condenser	Bottle (1 qt)	1 per shift	NH Content.
Line between Sponge Oil Cooler & Contact Condenser	Sponge Oil to Contact Condenser	Bottle (2 qt)	1 per shift	Distillation, RVP, Gravity.
Between Flame Arrestor and Boiler	Splitter Overhead Gas to Boiler	Evacuated Bomb (or Bag)	1 per shift	Gas Chromatograph: Hydrocarbons, Sulfur, (H_2S, RSH, COS, CS_2), H_2O, NH_3.

*See Table 8.13-2 for nomenclature

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Just ahead of Storage Tank	Total MIS Light Oil	Bottle (2 qt)	1 per shift	Distillation, RVP, BS&W, Viscosity, Gravity.
Aerosol Oil Line ahead of Storage	Aerosol Oil from T-52	Bottle (1 qt)	1 per day	Gravity, RVP, BS&W.
Outlet of Retort Oil Storage Tank	MIS Oil to AGR Area	Bottle (2 qt)	1 per shift	Distillation, Total N, Total S, Gravity, Viscosity, BS&W.
Boiler Feed Water Line ahead of Boiler	Boiler Feed Water Blowdown	Bottle (2 qt) (or Bomb for O_2)	1 per shift	pH, TDS, Alkalinity, SiO_2, Fe, Phosphate, Dissolved O_2.
Inlet to BFW Deaerator	Demineralized Water (BFW Makeup)	Bottle (1 qt)	1 per shift	pH, TDS, Alkalinity, SiO_2, Fe.
MIS Boiler Flue Stack	Flue Gas to Atmosphere	Bag Sample	1/wk (check in-line analyzers)	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO_x, CO.
Offgas Line ahead of the Flue Gas Absorbers	Flue Gas to Absorbers	Bag Sample	2 per week	SO_2, CO_2, O_2, CO, N_2, NO_x.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Feed to Recirculation Tank Systems	Regenerated Liquor to Absorber	Bottle (1 qt)	1 per day	pH, Gravity, Suspended Solids, Na, SO_2, $NaHSO_3$.
Downstream of Filter	FGD Filter Cake	Pint Container	As required	% Moisture, Na, CaO, Total Sulfur

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Shale Feed Conveyor	Shale Feed to AGR	Belt sample (install 3-stage sampler)	1 per shift	Fischer Assay
Rundown Oil Line between Retort and Tankage	Rundown Oil	Bottle (1 qt)	1 per shift	Gravity, Viscosity, Pour Point
Outlet from Condensate Tank	Retort Condensate to Spent Shale Cooling	Bottle (1 qt)	1 per shift	Organics, Metals, TDS, HCN
		Bottle (1 qt)	2 per shift	Visual for Hydrocarbons
Inlet of Make Gas Compressor	Retort Make Gas to Make Gas Compressor	Bomb	1 per shift	Chromatograph Analysis: HC, Sulfur, NH_3, HCN, H_2O, H_2, CO_2, N_2.
Overhead Gas Line from Make Gas Absorber	Make Gas Absorber Overhead	Evacuated Bomb	1 per day	Gas Chromatograph: HC, H_2S, COS, CS_2, CO_2, NH_2, N_2, HCN, CO, H_2O.
Outlet from Sponge Oil Cooler	Net Gas to Unisulf	Evacuated Bomb (or Bag)	1 per day	Gas Chromatograph: HC, H_2S, COS, CS_2, CO_2, CO, NH_2, N_2, HCN, H_2O.
Outlet from Debutanizer Reflux Accumulator	Gas from Debutanizer Reflux Accumulator	Evacuated Bomb (or Bag)	1 per day	Gas Chromatograph: C +.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
After Ammonia Scrubber	Unisulf Effluent Gas	Evacuated Bomb (or Bag)	1 per day or as required	Gas Chromotagraph: HC, H_2S, COS, CS_2, CO_2, CO, NH_3, N_2, HCN, H_2O.
Ahead of Unisulf Absorber	Unisulf Solution from Balance Tank	Bottle (1 qt)	1 per week or as required	Check chemistry per licensor requirement or recommendation.
After Sulfur Decanter	Sulfur to Storage	Solid container (cool sample)	1 per week or as required	Analyze for contaminants from Unisulf solution (Vanadium, Thiosulfates, HCN). Analyze for sales as required.
Outlet of Second Stage Deasher	Oil from Second Stage Deasher	Bottle (1 qt)	1 per shift	BS&W, Ash (inorganics).
Fractionator Outlet	Oil from Fractionation to OUG or Storage	Bottle (2 qt)	1 per day	Distillation, Gravity, Viscosity, Pour Point.
Inlet to Shaft Cooler	Combined Water to Shaft Cooler	Bottle (1 qt)	1 per day	Organics, Metals, TDS, HCN.
Inlet to Wetter	Seal Steam Condensing Vessel Blowdown to Wetter	Bottle (1 qt)	1 per day	Organics, Metals, TDS, HCN.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Outlet Stack Sponge Oil Stripper Reboiler	F-01 Stack Outlet (Sponge Oil Stripper Reboiler)	Bag	1 per week or as required to check O_2 analyzer	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO_x, CO.
Stack on Recycle Gas Heater	F-01 Stack Outlet (Recycle Gas Heater)	Bag	1 per week or as required to check O_2 analyzer	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO_x, CO.
Spent Shale Conveyor	Spent Shale	Channel Sample	1 per week	Organics, Metals, % Moisture.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Outlet Stack Sponge Oil Stripper Reboiler	F-01 Stack Outlet (Sponge Oil Stripper Reboiler)	Bag	1 per week or as required to check O_2 analyzer	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO_x, CO.
Stack on Recycle Gas Heater	F-01 Stack Outlet (Recycle Gas Heater)	Bag	1 per week or as required to check O_2 analyzer	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO_x, CO.
Spent Shale Conveyor	Spent Shale	Channel Sample	1 per week	Organics, Metals, % Moisture.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Natural Gas Supply to H Plant	Natural Gas to H Plant	Bomb	1 per day	Gas Chromatograph: N_2, O_2, HC, NO_x, Moisture, CO.
Stack on Reformer Heater	F-01 Stack Outlet (Reformer Heater)	Bag	1 per/wk or as req. to check O_2 analyzer	SO_2, NO_x, O_2, CO.
		EPA Method 5 (Isokinetic)	As required	Particulates, SO_2, NO $_x$ CO.
Inlet to V-09 PSA H_2 Unit	Product Gas to V-09	Bomb	1 per week to calibrate analyzer	Gas chromatograph: HC.
Between PSA and Hydrotreating Unit	H Gas from PSA Unit	Bomb	1 per week to calibrate analyzer	Gas Chromatograph: HC.
Oil Charge Heater Stack	F-01 Stack Outlet (Oil Charge Heater)	Bag	1 per/wk or as req. to check O_2 analyzer	SO_2, NO_x, CO, O_2.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Recycle Gas Heater Stack	F-02 Stack Outlet (H_2 Recycle Gas Heater)	Bag	1 per/wk or as req. to to check O_2 analyzer	SO_2, NO_x, CO, O_2.
H_2 Charge Heater Stack	F-03 Stack Outlet (H_2 Charge Heater)	Bag	1 per/wk or as req. to check O_2 analyzer	SO_2, NO_x, CO, O_2.
Unionfiner Feed Line	Dearsenated Oil to Unionfiner	Bottle (1 qt)	1 per shift	Analyze for Arsenic
Product Line ahead of Storage Tanks	Unionfiner Product to Storage	Bottle (2 qt)	1 per shift	Distillation, Gravity, Viscosity, Pour Point, Sulfur, Nitrogen.
Bottom outlet of Sour Water Stripper	Stripper Bottoms	Bottle (1 qt)	1 per shift	NH_3, H_2S, CO_2.
Between Fractionator Reflux Drum and Storage Vessel	Anhydrous Ammonia to Storage	Bomb	1 per shift	Moisture (as required for sales).

TABLE 8.13-1 (Contd)
Process Montoring

Location	Stream	Type of Sample	Frequency	Analysis
Bottom Outlet of Phosam Fractionator	Phosam Fractionator Bottoms	Bottle (cool)	1 per shift	NH_3, % Phosphoric Acid.
Sour Gas from Unionfiner ahead of Sour Gas Absorber	Sour Gas to Absorber	Bomb	1 per week as required to check analyzers	Gas Chromatograph: HC, Sulfur, CO, CO_2, NH_3, (as recommended by licensor).
Outlet of Sour Gas Absorber	Sour Gas from Absorber	Bomb	1/wk (check analyzers)	Gas Chromatograph: HC, Sulfur, CO, CO_2, NH_3.
Outlet of Caustic Wash Tower	Gas to Fuel Gas System	Bomb	1/wk (check analyzers)	Gas Chromatograph: HC, Sulfur, CO, CO_2, NH_3.
Ahead of Claus Feed Gas Cooler	Sour Gas to Claus Plant	Bomb	1/wk (check analyzers)	Gas Chromatograph: HC, Sulfur, CO, CO_3, NH_3.
Outlet of Tail Gas Scrubber	Claus Tail Gas to MIS Boilers	Bomb	1/wk (check analyzers)	Gas Chromatograph: HC, Sulfur, CO, CO_2, NH_3, NO_x.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Discharge from API Separator	API Discharge Water	Bottle (1 qt)	1 per shift	Organics, Metals, TDS.
Blowdown Pond	Blowdown Pond Discharge to Spent Shale	Bottle (1 qt)	1 per shift	Organics, Metals, TDS.
Sewer Plant Outfall	Sanitary System Discharge	Bottle (3 qt)	1 per shift	BOD, Suspended Solids, Fecal Coliforms, Residual Chlorine, pH, Oil and Grease
Inert Gas Line	Inert Gas System	Evacuated Bomb	1/wk (check analyzer)	O_2.
Control Room	Instrument Air	Evacuated Bomb	1/wk (check moisture analyzer	Moisture.
Cooling Tower Blowdown Line	Cooling Water Tower Blowdown	Bottle (1 qt)	1 per day	pH, Scale Inhibitor.
		Bottle (1 qt)	1 per week	Residual chlorine.
Ahead of Treatment Ponds	Mine Water Discharge	Bottle (2 qt)	1 per day	pH, Metals, Fluoride, TDS.
After Water R/O Unit	Potable Water	Bottle (1 qt)	1 per day	Chlorine, TDS, Fluoride.

TABLE 8.13-1 (Contd)
Process Monitoring

Location	Stream	Type of Sample	Frequency	Analysis
Inlet of Treatment Unit	Electrodialysis/Reverse Osmosis Unit Inlet	Bottle (1 qt)	1/day (check analyzers)	pH, Metals, Fluoride, TDS, Alkalinity.
Outlet of Treatment Unit	Electrodialysis/Reverse Osmosis Unit Outlet	Bottle (1 qt)	1/day (check analyzers)	pH, Metals, Fluoride, TDS, Alkalinity, Silica.
Outlet of Ion Exchange Columns	Demineralizer Outlet	Bottle (1 qt)	1 per day	TDS, Silica, Fe.
Outlet of Fuel Gas Blending Drum	Fuel Gas Blend Drum Outlet	Evacuated Bomb	1 per day	Gas Chromatograph: HC, H_2S, COS, CS_2, CO_2, CO, NH_3, N_2, HCN, H_2O.

TABLE 8.13-2

Nomenclature

AGR	-	Aboveground Retort Facilities
BFW	-	Boiler Feed Water
BS & W	-	Bottom Sediment and Water
CaO	-	Lime or Calcium Oxide
COS	-	Carbonyl Sulfide
CS_2	-	Carbon Disulfide
F-01 Stack	-	Stack in OUG
F-02	-	Stack in OUG
F-03	-	Stack in OUG
FGD	-	Flue Gas Desulfurization
HCN	-	Hydrogen Cycanide
MIS	-	Modified In-Situ Facilities
$NaHSO_3$	-	Sodium Biosulfite
OUG	-	Oil Upgrading Facilities
PSA	-	Pressure Swing Absorber (Gas)
RSH	-	Mercaptan
RVP	-	Reed Vapor Pressure

determination that such pollutants are present at levels that raise legitimate concern for personal health and safety, or for the general environment. The sample drawn for such analysis should be representative of the steady-state operation. Steady-state should reflect nominal operation of the plant in terms of production and overall equipment performance. Such a condition would first occur approximately 6/1/89 for the AGR facility. The MIS facility would be about one year later than the AGR.

There are at least two basic approaches to establishing the presence of undesirable pollutants. The one most commonly used by the regulatory agencies is the comparison of an analytical screening to a list of pollutants established by the agency. This procedure is appropriate provided the list includes all pollutants the process could produce and does not require an extensive search for pollutants that may not be present. Unfortunately, the list approach is faulty on both counts. There is no reasonable way anyone can assemble a list of pollutants that is totally inclusive of undesirable pollutants for a process from which there are no steady-state data. As a practical matter, such an attempted list will result in many chemical species listed that will never be found, particularly at concentrations of concern.

The approach selected for use by CB utilizes the scientific method. By this method a more thorough assessment can be made as to the presence of all pollutants and concentrations of concern. The method also focuses the analytical resources in an efficient manner avoiding unnecessary analysis. (See Figure 8.13-1.)

The analytical scheme for organics can take several possible routes. The work done by Leenheer and Huffman is the one proposed by CB. Leenheer and Huffman did basic methods development for the analysis of organics in retort process water. The following is a summary of Leenheer and Huffman's procedure:

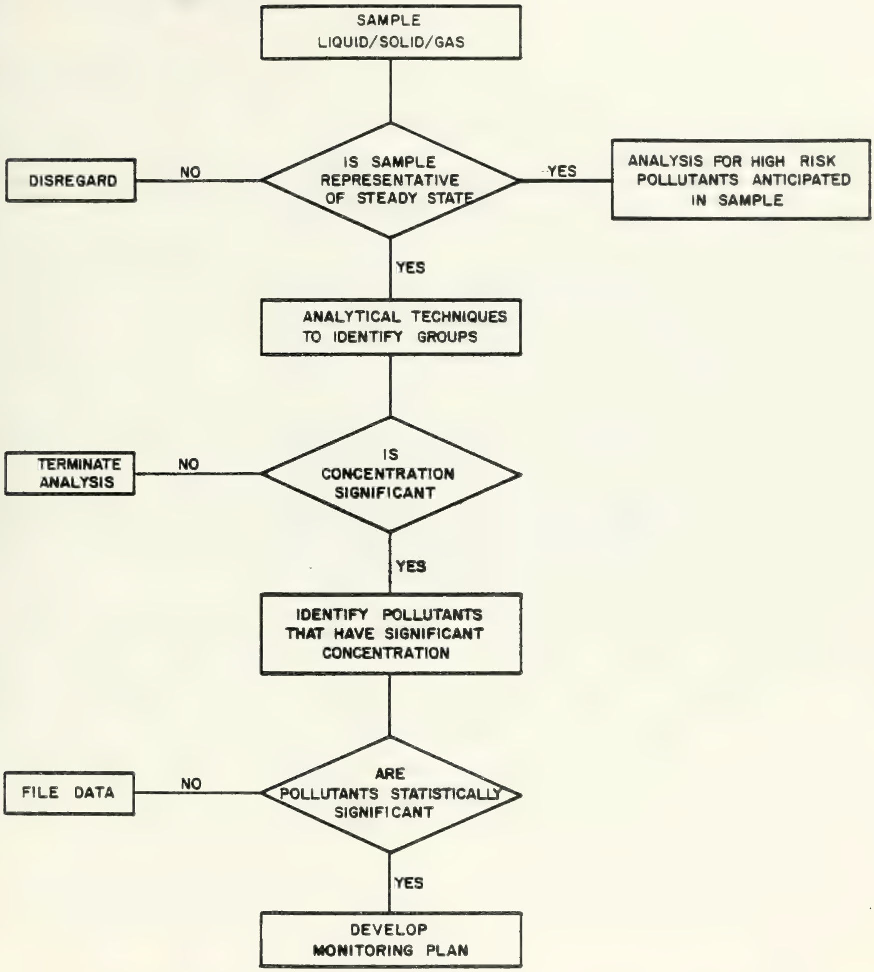


FIGURE 8.13-1 GENERAL APPROACH TO SCREENING ANALYSIS FOR UNREGULATED POLLUTANTS

Hydrophilic Bases	Aromatic amines except pyridine
Hydrophilic Acids	Aliphatic carboxylic acids > five carbons, aromatic carboxylic acids, ketones
Hydrophilic Neutrals	Hydrocarbons, aliphatic alcohols, amides, esters, ketones, and aldehydes of > five carbon, pyrroles, phenols, and indoles
Hydrophobic Bases	Aliphatic amines, pyridines, amino acids
Hydrophobic Acids	Aliphatic acids of ≤ five carbons and polyfunctional acid
Hydrophobic Neutrals	Aliphatic amides, alcohols, aldehydes, esters and ketones ≤ five carbons, polyfunctional alcohols, carbohydrates

If the concentrations of the hydrophilic and hydrophobic groups are large enough to warrant further investigation, then the selected group or groups would be further broken down and their respective components reviewed in terms of concentrations. For example, assume the hyprophobic neutrals showed a significant concentration, then neutrals would be broken down into their sub-groups: aliphatic amides, alcohols, aldehydes, esters, ketones ≤ five carbons, polyfuntional alcohols and carbohydrates. Each subgroup would be evaluated to see if significant concentrations were evident. Those subgroups with significnat concentrations would be analyzed for either specific chemical species or groups.

Unregulated inorganic pollutants are not difficult to address analytically because of their limited number and analytical techniques are available for their analysis. Toxic inorganic species are primarily the "heavy metals". It is most practical to screen a sample for heavy metals using the atomic absorption (AA) or X-Ray fluorescence technique. This procedure is appropriate if the sample were

8.13 Process Monitoring

drawn from either liquid, solid or gaseous systems. Upon review of the results, species with significant concentrations can be identified.

The determination of significant concentrations is the most difficult task. If the sample is a process sample representative of possible personnel exposure levels, then the TLV's set by the American Conference of Governmental Industrial Hygienists (ACGIH) will be used as reference. If the sample represents materials that will be directly placed into the environment, then literature regarding impacts on wildlife and agriculture will be used as reference.

The data collected from the screening analysis will provide the basis for selecting parameters and monitoring frequency of selected pollutants. The determination would be made by statistically determining the most significant surrogate parameters from those analyzed in the screening period. A monitoring program based on specific goals utilizing statistically significant parameters will provide the highest degree of usable information.

8.0 DEVELOPMENT MONITORING PLAN

8.14 Quality Assurance

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

Page

LIST OF FIGURES

8.0 DEVELOPMENT MONITORING PLAN

8.14 Quality Assurance

8.14.1 Introduction and Scope

The term quality assurance as used in this document refers to two types of activities: (1) activities to provide a quality product and (2) activities to provide assurance that the quality control system is performing adequately (EPA 1976).

The objective of the CB monitoring program is to develop an environmental data base that can be used by analysts to assess and mitigate potential environmental impacts. Consequently, the goal of the quality assurance program outlined below is to obtain an environmental data base of high quality.

There are five primary steps in the process to develop an adequate data base: designing the experiment, taking the sample, measuring the sample, recording the measurement, and scanning the data for erroneous or questionable values in a timely fashion for field sampling to be repeated, if need be, or systems dependent monitoring started. Experimental design is treated in respective sub-sections on monitoring. These steps comprise dozens of activities with many opportunities for human and instrument error. The steps taken to develop a data base and the major quality assurance activities are identified in Table 8.14-1. Each is described in greater detail in subsequent sections which are organized by media (i.e., air, water, noise, biology, subsidence).

8.14.1.1 Quality Assurance Plan

The CB quality assurance plan was developed as the backbone of a well directed and managed quality assurance program. The plan is documented to ensure that it is applied systematically and consistently. This plan is also flexible so that changes in sampling procedures or instrumentation can be readily incorporated into the plan.

TABLE 8.14-1

Development of Environmental Data Base

Media	Data Collection (QA-1)	Measurement (QA-2)	Form of Data	Data Transmitted to:	Data Logged In and Scanned (QA-4	Data Reduced (QA-5)	Data Keypunched (QA-6)	Entered Into Data Base (Form of Storage)	Data QC'd for Outliers	Monitoring Reports Prepared (Output) (QA-7)
Air	Automatic-sensors	Measurement device	Magnetic Tape	CB Data Processing (DP)	NA	NA	NA	Computer	X	Computer Tables and Time Series Plots (T&P)
			Strip Chart	DP	X	X	X	Computer	X	Computer T&P
	Manual-instrument reading	Measurement device	Data Log	DP	X	NA	X	Computer	X	Computer T&P
Water	Automatic-flow gage	Measurement device	Strip Chart	DP	X	X	X	Computer	X	Computer T&P
	Manual-instrument reading	Measurement device	Data Log	DP	X	X	X	Computer	X	Computer T&P
	Manual-samples	Laboratory	Lab Report	DP	X	NA	X	Computer	X	Computer T&P
	USGS			DP[a]	NA	NA	NA	Computer[a]	X	Computer T&P
Noise	Manual-instrument Reading	Measurement device	Strip Chart	DP	X	NA	X	Hard Copy	X	Manual T&P
Biology	Manual-instrument reading	Measurement device	Data Log	DP	X	NA	X	Computer	X	Computer T&P
			Strip Chart	DP	X	X	X	Computer	X	Computer T&P
	Manual-observation	Field observer	Data Log	Consultant	NA	NA	NA	Computer	X	Computer T&P
	Manual-photography	Field observer	Photographs	Photo lab file	NA	NA	NA	Photo Lab	NA	Photographs reproduced
			Strip Chart	DP	X	X	X	Computer	X	Computer T&P
	Manual-observation	Field observer	Data Log	Consultant	NA	NA	NA	Computer	X	Computer T&P
	Manual-photography	Field observer	Photographs	Photo lab file	NA	NA	NA	Photo Lab	NA	Photographs reproduced
	Manual-Landsat	Satellite & Ground Receiving Station	Magnetic Tape	United Computing Service (UCS)[b]	NA	X	NA	Computer	X	NA
	Manual-survey reading	Measurement device	Data Log	DP	X	NA	X	Computer	X	Computer T&P

FOOTNOTES:

QA-1 Quality assurance handbooks specify: data collection procedures; methods to operate, maintain and calibrate instruments; documentation requirements and so forth.

QA-2 Quality assurance handbooks specify: data measurement procedures (including laboratory practices); methods to operate, maintain, and calibrate instruments; documentation requirements and so forth.

QA-3 The data processing quality assurance handbook specifies the data procedures including those referenced in notes QA-4 through QA-7.

QA-4 Data are logged in, assigned a library code, and preliminarily scanned for quality.

QA-5 Data that are to be entered into the computerized data base are manually digitized and 10% or more of the data digitized a second time as a quality check.

QA-6 Quality is achieved by key punching all data twice and by scanning the data for outliers after it has been entered into the computer.

QA-7 The monitoring reports are analyzed for atypical trends or values beyond present limits or rates of change that could be attributed for faulty data.

ADDITIONAL FOOTNOTES:

[a]Approximately 25% of the water quality data in the Cathedral Bluffs data base are collected and processed by USGS. The data are transmitted to Cathedral Bluffs via a telephonic computer connection.

[b]The Cathedral Bluffs data base is maintained on tape at Cathedral Bluffs; during the data reduction process the UCS system in Kansas City is used for temporary storage.

8.14 Quality Assurance

The quality assurance plan is comprised of the elements explained below.

(1) The plan is driven by a general goal to provide overall direction to the subsequent elements.

(2) Specific goals guide the quality assurance activities in each topical area of inquiry (e.g., air, water).

(3) The quality assurance programs lay out the specific procedures that are used to collect samples, measure parameters (or variables), and process data so as to assure quality at each step.

(4) The implementation plan identifies responsibility and timing for conducting the quality assurance programs.

(5) Audits of the field data and systems procedures are identified as part of the quality assurance plan.

CB is presently conducting quality assurance as part of its data gathering and recording efforts. Most of these programs have recently grown to the point where quality assurance documents are required to support quality assurance activities.

8.14.1.2 Quality Assurance Policy

CB is dedicated to a program to collect, process, and analyze quality environmental information to support regulatory requirements and foster precedent environmental planning. An environmental data base is recognized as the foundation of this process. The Project is dedicated to a program to develop and maintain a comprehensive data base that contains reliable information that meets analytical goals for precision, accuracy, and completeness.

8.0 DEVELOPMENT MONITORING PLAN

8.14 Quality Assurance

8.14.2 Air

8.14.2.1 Quality Assurance Handbook

Quality Assurance activities are presently prescribed in the EPA-approved CB Air Monitoring Quality Assurance Manual and Standard Operating Procedures, developed in 1981 and periodically updated; it is incorporated by reference and will only briefly be summarized here. The handbook includes the following elements.

- Monitoring procedures;
- Procedures to operate and maintain equipment;
- Methods to screen data for quality;
- Procedures for corrective action;
- Other quality assurance procedures such as reporting.

The discussion about equipment includes the following: a list of equipment by type and parameter measures, specifications, calibration techniques, operating procedures, trouble shooting, a list of spare parts required, and maintenance activities.

8.14.2.2 Training

On-site monitoring is accomplished by a highly qualified station operator/ instrument technician. He has received training on the operation and maintenance of the monitoring system as well as instruction by instrument manufacturers on their instruments. The training embraces repair, calibration, record keeping, and station check procedures.

8.14.2.3 Sample Collection and Measurement

Data from the air quality and meteorological instruments are recorded in three ways. The analog recorder provides strip charts, the data acquisition system records the digital data on magnetic tapes, and the data aquisition system printer provides printouts of all recorded values. This redundant system minimizes the chances for erroneous or missing data.

Sample quality is assured through control checks on the performance of the sample collection system. These checks are conducted before, during, and after sample collection. They are performed in the manner outlined in Volumes II and III of EPA's Quality Assurance Handbook of Air Pollution Measurement (EPA 1977a, 1977b).

The quality of the measurements is screened by the trailer operator. Measurements are compared with historic data to identify extreme values. If there are apparent problems, they are recorded as are any corrective actions.

The digital data acquisition system logs data averages once each five minutes, giving 12 average values per hour. See Section 8.6 for a discussion of sampling frequency. An hour of data is considered valid if it includes at least six five-minute periods in presence of missing data; i.e., this allows a minimum of six five-minute-average values to define an hourly average. Strip chart data are considered to represent the hour if more than 30 minutes of valid record are recorded.

Data collected in the first 15 minutes after calibration are generally discarded. Data are considered erroneous if any of the status indications or the station log suggest instrument malfunctioning. In addition, air quality data collected in the first 15-minutes after a brief power outage (less than 10-minutes), in the first hour after a medium duration outage (up to one hour), or in the first four hours after longer outages are discarded as unreliable. Any anomalous data reflecting signal spikes or dropouts with a response rate faster than that ascribable to atmospheric phenomena (e.g., a tripling of NO_x levels

from one scan to the next, followed by a return to the old level on the succeeding scan) are deleted as an artifice caused by the system.

As an additional check, the calibrated data are also screened manually. First, data are scanned to detect extreme values. When a spurious value is obtained, it is checked for validity. When invalid data are deleted, a record of these deletions is maintained by code in the diurnal tables (hourly values) contained in the 6-month data reports. All raw data values are retained on tape; only the validated data are reported.

8.14.2.4 Sampling Equipment

8.14.2.4.1 Maintenance and Backup

The equipment is installed and maintained in accordance with manufacturers instructions and CB experience with the instruments. A stock of spare parts is maintained in accordance with manufacturers recommendations and the dictates of experience. Key parts, such as pumps, valves, monitors, lamps, and circuit cards are needed for measurement, calibration, and data acquisition systems.

8.14.2.4.2 Station Check

SO_2, H_2S, and NO/NO_x instruments are zeroed and checked at one point (i.e., full span) with the Monitor Labs 8500 Calibrator. The O_3 instrument has an internal zero and span check. The CO instrument has an internal zero, and the span is checked with a reference gas bottle of approximately 40 ppm CO. This daily check is performed automatically at midnight by the data logger. The station operators check these values and recalibrate if values are 10-15% in error; maintenance is performed if there are larger variations. Details of work performed are noted in a daily log book.

8.14 Quality Assurance

The zero and span values whose magnitudes are determined by a monthly multipoint calibration are entered into the respective instruments daily, and the instrument responses recorded. The calibration factors are calculated based on these data, and they are applied to the monitored data for the next 24 hours or until the next zero and span checks occur. This approach ensures that the instrument drift problems are adjusted on a daily basis.

Occasionally the instrument zero and span checks yield values which exceed established control limits. This can be caused by excessive instrument drifts and unstable calibration sources. In this case, the instruments will be readjusted or calibration sources replaced as soon as the problem is detected.

8.14.2.4.3 Calibration

Multipoint calibrations of all air quality instruments are performed monthly. Instruments are also multipointed if major maintenance is performed. The multipoint calibration is conducted by the station operator.

The Dasibi calibrator is used to obtain a multipoint calibration of all instruments. The Dasibi contains mass flow meters for dilution of concentrated bottle gases. The calibrator contains an ozone generator; its concentrations are checked with a Dasibi ultraviolet analyzer. This calibrator provides very stable and precise concentrations for checking the linearity of instruments and for checking the concentration of the daily one-point-calibration sources (called "span" values).

The concentration cylinders are ±1% National Bureau of Standards traceable and are checked every six months. The mass flow meters in the calibrator are checked every six months.

8.14 Quality Assurance

The Hivols contain mass flow controllers which are checked monthly with a test meter. The wind sensors are checked every six months off-site by the manufacturer via wind tunnel tests. Temperature sensors are checked with a National-Bureau-of-Standards-traceable thermometer. In general, all instruments are calibrated by National-Bureau-of-Standards-traceable methods, when possible.

8.14.2.5 Data Processing

8.14.2.5.1 Data Processing Procedures

Processing typically includes data reduction and entry into a computerized data storage system (see Table 8.14-1). The steps in data production are presented below in the sequence in which they occur. This discussion pertains to the treatment of air quality data as well as water, biology, noise, and subsidence data.

Data Submittal. Data are submitted to the data processing section (DP) on a regular schedule. (Refer to the sections on monitoring for information on the frequency of sampling.) If data do not arrive at DP according to schedule, they are traced to find the source of the problem.

Log In. Once received, data are logged in to provide a record that they are received. The data are assigned a computer library code so that they can be located at all times.

Data Scan. All data are manually scanned by data processing personnel for quality, completeness, and special conditions. The data are systematically checked for outliers (data that vary significantly from the norm), sampling station identification, date, and notes made by field personnel that explain abnormal conditions that may affect data quality. Scanning is conducted by senior DP technicians familiar with the data and data quality goals.

8.14 Quality Assurance

Data Reduction. Data in the form of strip charts and punched tape are converted into a digital (numeric) form. Special templates are used to interpret strip charts and convert information into hourly averages.

Data Entry. Data are key punched for entry into the data base. The data are entered twice to verify the accuracy.

Data Review. After the keypunched cards have been read by the computer, a printout of the data set is obtained for a quality review. The focus of the review is to ascertain keypunch and format errors; however, a general quality scan also occurs (see Data Scan above).

Reformat and Merge. A validated computer program is used to reformat the data and merge them with historical data.

Data Reports. CB produces semi-annual data reports in accordance with the C-b Tract Lease Stipulations. These reports contain summary tables and time plots of the data. The output is subjected to review to obtain comparisions with past data and to note atypical trends. The latter are analyzed for possible data errors. If errors are discovered, and if they appear in data reports already issued, the following actions are taken:

- The correction is made in the computerized data base and is reflected in the next report issued.

- The data correction is noted in a special table and a record of all corrections is included in the data report.

8.14.2.5.2 Outliers and Missing Data

When outliers are detected, they are analyzed to determine the cause. If the outlier is determined to be the result of data collection, measurement, or processing error, the erroneous value is removed from the data base and the correct value (when it can be assessed) is entered in its place. If the reason for the outlier cannot be attributed to the above causes, the value is retained in the data base. The analysis of outliers and any corrective actions are documented; by such documentation, the OSPO is made fully aware of specific treatment of all outliers. Statistical and manual screening procedures are used to detect outliers in air and water data.

Missing data are coded to distinguish them from zero values. The causes for the data gap are also coded into the system. Data may be infrequently generated by statistical techniques to fill gaps in the data base if required by regulations (e.g. ozone). Such data are coded for clear identification. To date there have been no requirements for such ozone data additions.

8.14.2.5.3 Handbook and Training

The data management procedures are further discussed in Section 8.15.

The DP staff receives training in several ways. In addition to being technically qualified, each new member receives on-the-job training from more experienced staff. New personnel become familiar with the DP procedures and CB hardware and software. Once or twice a year a representative from the Techncial Systems Department within the Corporate headquarters offers specialized instruction to the DP staff. The instruction encompasses new software, upgraded software, and refresher information. In addition, video classes are supplied on programming, computer languages and the like.

8.14 Quality Assurance

Similarly, field personnel are periodically sent to instrument manufacturers schools to obtain most recent information on instrument maintenance and repair procedures.

8.14.2.6 Auditing

CB has a program to audit monitoring procedures. The program was designed as a quality assurance measure, as well as to ensure compliance with the Lease Stipulations and all applicable environmental regulations.

There are two types of audits: an audit of the output (i.e., quality of the data) and an audit of the quality assurance system. These latter audits are called systems audits and are performed at each stage of data development: collection, measurement, and processing.

Audits of output are conducted in several ways. For example, to isolate possible variances in data due to the operator, the auditor (a person other than the usual operator) will perform or observe the procedure being audited. To identify possible instrument error, an independent and calibrated instrument is used for a similar comparitive check. Other techniques include spot checks of calculations, data reduction, other potential sources of human error, and the entry of dummy data into the system to ensure that it is reduced, verified, and entered into the data base properly.

Systems audits are qualitative on-site inspections of the quality assurance techniques that are actually being used. The quality assurance handbooks are a key measure of performance. The system audits embrace all facets of the quality program, for example:

- Organization and responsibility - Is the quality assurance organization operational?

8.14 Quality Assurance

- Sample collection - Are written sample-collection procedures available, and are these followed as written?
- Sample analysis - Are written analysis procedures available, and are these followed as written?
- Data validation - Is a list of criteria for data validation available, and is it used?
- Calibration - Are written calibration procedures available, and are these followed as written?
- Interlaboratory tests - Are results from interlaboratory testing reviewed?
- Preventive maintenance - Is the preventive maintenance schedule being followed as recommended in the quality assurance handbook? (EPA 1976)

Audits have historically been done in two ways:

(1) In 1981 and 1982 audits were conducted by the Grand Junction Environmental Services Department on data gathered by the C-b Tract staff utilizing separate audit instruments.

(2) The more widely used technique is through the use of third party audits. In 1982 and 1983 both the EPA and the State APCD have alternatively audited the C-b Tract. Results of all audits are summarized by the auditors in reports and further summarized in the six-month data reports to the OSPO.

In addition, environmental assessments for the entire program have been accomplished at least annually by the Project partners.

8.14.3 Water

8.14.3.1 Quality Assurance Handbook

Quality assurance procedures are presented in a document titled Quality Assurance Program for Hydrology. It is incorporated by reference and only

only briefly summarized here. This report was issued in 1981; procedures are periodically updated. The handbook addresses quality assurance at the four stages of data development: field sampling, field laboratory, analytical laboratory, and data handling. The comments below reflect the contents of that handbook.

8.14.3.2 Training

New sampling and laboratory personnel receive field training from experienced peers and if necessary an environmental engineer from the CB Environmental Services Department. Personnel are taught sampling and measurement techniques including handling, maintenance, repair and calibration of instruments, and recording requirements.

8.14.3.3 Sample Collection and Measurement

The CB hydrologic monitoring program includes a variety of water sources such as streams, springs, seeps, and ponds, alluvial wells and bedrock wells. Standardized sampling techniques are utilized whenever possible; however, the variety of sampling situations necessitates the development of individual sample protocols. The quality assurance handbook presents the standardized techniques. The handbook will, therefore, include specific guidance required to facilitate consistent sampling procedures.

Water depth or flow is measured in several ways: sounding device, Stevens Recorder, and flumes and chart recorders.

Stream samples are typically taken at the center of the stream (mid-width and mid-depth). Agricultural or other time dependent runoffs necessitate the use of time-integrated sampling techniques. When sampling does not occur at gaging stations, stream discharge is determined from the cross station and depth of the stream.

8.14 Quality Assurance

Shallow alluvial wells are generally less than 100 feet deep; therefore, samples can be obtained by pumping. Generally two to three times the quantity of the water in the well bore is pumped before a sample is taken. The pumped water is discharged so that it will not directly return to the aquifer being sampled. Water levels are measured prior to taking water quality samples.

In the bedrock wells, there are two to three strings (narrow tubes 2 1/2 in. in diameter) that provide access to water at prescribed points in the aquifer. The small size of the tubes prevents pumping or bailing. A swabbing technique has been used until recently; it has been replaced by the Barcad technique.

Most water samples are taken as a single gross sample, divided into bottles each requiring different pre-analysis treatments with preservatives. Samples are treated with preservatives immediately after they are drawn. For each parameter to be tested, the quality assurance handbook specifies the container number, container volume, type of container, and preservative treatment (See Table 8.14-2).

A record is made of every visit to a field monitoring site in the Field Sampling Logbook. The following information is included:

- Site identification, location and description;
- Date and time of monitoring visit;
- Field measurements including flows and water levels;
- Sample collection activities;
- Any observations relevant to the condition of the site or sample (i.e., physical appearance of water, changes in conditions of station, weather conditions);
- Reaction of water to addition of preservatives;
- Any deviations from the established monitoring procedure;
- Name(s) of person(s) performing the monitoring.

TABLE 8.14-2

Water Sampling and Preservation Procedures, Schedule I
(Effective July 7, 1981,
for CB, NPDES, Special)

Bottle #	Required Volume (ml.)	Container*	Preservative	Parameters
1	500	P	HNO_3 to pH <2 0.05% $K_2Cr_2O_7$	tHg
2	500	P	HNO_3 to pH <2 Unfiltered	Total metals
3	1000	P	HNO_3 to pH <2 Filtered 0.45 membrane	Dissolved metals Hardness (Ca+Mg), sAl
4	1000	P	Unfiltered Untreated, cool 4°C	tAlk, Cl, F, CO_3, HCO_3, SO_4, TDS, TSS, NO_3, SiO_2, SCN, S_2O_3, Br, NO_2
5	1000	P	Unfiltered Untreated, cool 4°C	BOD_5, turb.
6	2000 2 each 1000	G PSC	H_2SO_4 to pH <2 Cool 4°C Unfiltered	NH_3-N, tot. PO_4, $NO_3 + NO_2$ COD, Kjeldahl-N, DOC, TOC
7	2000 2 each 1000	G PSC	H_2SO_4 to pH <2 Cool 4°C Unfiltered	Phenols, Oil & Grease
8	1000	P	HNO_3 to pH <2 Filter 0.45 membrane	Radiochemistry: gross & Ra^{226}, Sr^{90}, Cs^{137}, natural U
9	500	P	Cool 4°C Zinc Acetate Unfiltered	Sulfide, $tS^{=}$
10	1000	P	Cool 4°C NaOH to pH >12 Unfiltered	CN
11	500	G PSC	Filter Ag membrane Untreated	Fractionation of dissolved organic carbon
12	250	G	Sterile (special bottles available G.J. Lab)	Total coliform Fecal coliform
13	1000	G TLC	Cool 4°C Untreated	MBAS, pyridine PNA, organics

*Legend: P: Polyethylene   t: Total
G: Glass   PSC: poly seal cap
S: Soluble   TLC: teflon lined cap

On-site determinations: D.O. pH, temp., conductivity, flow, color, visible oil and grease (sheen).

8.14 Quality Assurance

Whenever field measurements are made for either water level, water quantity or quality, the new reading is compared to previous data for that site. If the new reading shows large variation from the previous data, the site identifier (for example, well string number) is verified and the measurement is repeated, where feasible.

8.14.3.4 Sampling Equipment

The primary equipment used in well sampling is the depth sounder, Stevens Recorder, and Barcad sampler. In each case extra instrument and parts are maintained on site. The field personnel maintain and improve the equipment to maximize its performance. CB recently acquired a new instrument that can be lowered into a well for in situ and simultaneous measurements of temperature, pH, specific conductivity, and dissolved oxygen. This instrument is currently being tested in the field to ascertain accuracy, reliability, ease of use and so forth.

8.14.3.5 Laboratory

Water samples collected at the C-b Tract are analyzed at the Tract field laboratory and at the analytical laboratory in Grand Junction; the Grand Junction lab is certified by the Colorado Department of Health for drinking water analysis.

8.14.3.5.1 Field Laboratory

The quality assurance practices at the field laboratory are specified in the Quality Assurance Program for Hydrology. The analytical procedures conducted at the field laboratory include measurements of the following: pH, conductivity, total suspended solids, and dissolved oxygen. These measurements are conducted in accordance with Methods of Chemical Analysis of Water and Wastes, published by EPA in 1979. This manual also provides the basis for the methods of filtration and sample preservation utilized by the laboratory.

8.14 Quality Assurance

The CB quality assurance handbook also presents specific techniques to be used to perform all typical laboratory activities. For example, the four-step procedure for cleaning glassware and equipment is augmented with special procedures for dealing with contamination by trace metals and trace organics. These special procedures are invoked if the periodic analysis of blank samples reveals contaminants.

The field laboratory uses a Mettler A30 single pan analytical balance. The methods to operate and maintain the accuracy of the balance are laid out in the handbook. The balance is calibrated by the laboratory staff every six months or whenever the balance has been subject to jarring, vibration, or misuse. Parallel procedures are specified for the following analytical equipment.

- pH meter - calibration checked frequently when many samples are tested.

- Conductivity instrument - calibrated daily using a standard solution.

- Dissolved oxygen instrument - daily calibration by the air calibration technique and monthly calibration using samples analyzed by the Winkler Titration Method.

The laboratory equipment is maintained according to manufacturer's specifications. There are no duplicates of major instruments; however, component parts are retained as required.

Quality assurance is also fostered by periodic analysis of blank, spiked, and duplicate samples.

Any information concerning analyses of samples that takes place in the field laboratory is recorded in the laboratory notebook. The information recorded for

each analysis includes the sample identification numbers, the type of analysis, raw data, calculations, final results, any pertinent comments, the date, and the signature of the analyzer. The notebook is also used to record any atypical observations made during sample handling and preservation, e.g., a change in the character of the sample upon addition of preservative or a potential contamination occurrence such as dust falling into the sample. Such observations also include the sample identification number, the bottle numbers, date, and signature of the observer.

8.14.3.5.2 Analytical Laboratory

The analytical laboratory is certified for drinking water analysis by the Colorado Department of Health. State inspectors have inspected the facilities, record keeping, and quality assurance program. Furthermore, State-of-Colorado samples have been analyzed in the presence of state inspectors. The CB laboratory has received commendation from the state for its quality assurance program and the speed and accuracy of analysis.

The laboratory is operated under a systematic and rigorous quality assurace program. The progression of the samples through the laboratory and the points of quality assurance are depicted in Figure 8.14-1. The quality assurance program consumes approximately 10 to 20% of staff time. The elements of this program and the results of intra-laboratory testing are documented in Water Quality Analysis Control Procedures for Cathedral Bluffs Laboratory which was issued in March, 1980.

8.14.3.6 Data Processing

Water quality data are processed in the manner described in Section 8.14.2.5 Specific procedures that pertain to water data follow:

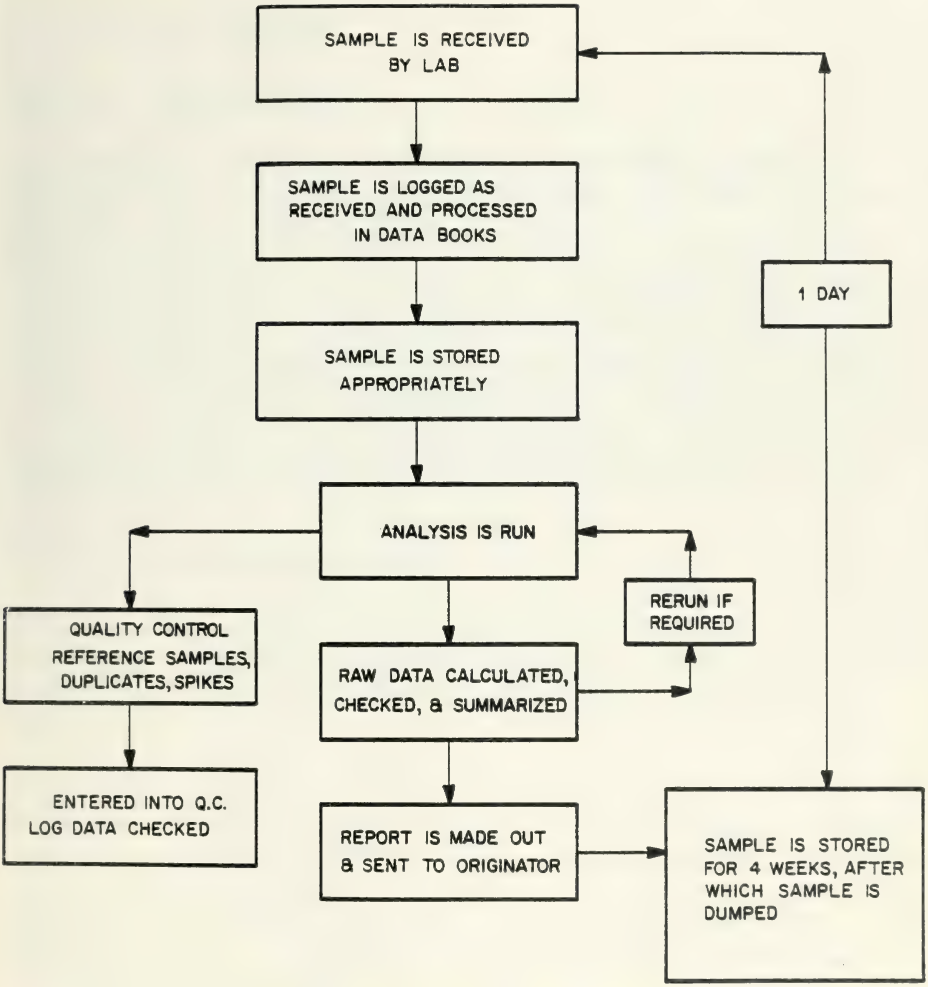


FIGURE 8.14-1
FLOW OF SAMPLES IN ANALYTIC LABORATORY

8.14.3.6.1 Inspection of Data

When data are submitted to Data Processing, environmental engineers in Environmental Services screen the data for each sample. An examination unique to water is the test for chemical consistency. One part of the test involves summing the concentrations of the major cations (positive charge) and anions (negative charge) within a sample to verify that they are approximately equal. Another test consists of summing concentrations of various dissolved species within a sample and comparing the sum with the measurement of total dissolved solids. The concentrations of trace compounds are also screened for unusually high or low values. If data are found questionable, they are verified with the performing laboratory. Unresolved data aberrations are documented in a memo to the data file.

8.14.3.6.2 Outlier Tests and Response

After data have been reviewed for internal consistency they are input into the computerized data file. Once merged with historic data, tables and plots are produced, and a manual check is made to identify outliers (see Section 8.14.2.5).

Criteria for statistically identifying a new input value as an outlier will be developed from the statistical characteristics of the previously accumulated population of data for the specific variable (water quality parameter) and sample site. For many trace elements, these criteria will be defined simply as an exceedance of a selected concentration. For major species, which display a high degree of variation, the criteria will be based on the distribution and mean of the previously acquired data.

Detection of an outlier value (under the present manual and future statistical techniques) initiates an immediate response procedure. This procedure calls for retesting the same sample (subject to availability) for the outlier variable. Should the new observation be more consistent with the historical samples, its value is entered into the data base in place of the previous value. If the new observation is also in the outlier range, or if none of the old sample remains for retesting, the sample site is resampled and tested immediately. If this observation is not an outlier, it replaces the original outlier value in the data base. If it is an outlier, then the mean of all three outlier values (the initial outlier, the retest outlier, and the resampled outlier) is entered into the data base. A permanent record of all outliers and response procedures is kept and reported in the six-month data reports to the OSPO.

Use of this procedure eliminates values resulting from spurious sources (such as sample or site contamination, analytical error, or sample mix-up) from the data base. However, an abrupt change in the water quality of the sample source that persists through the outlier response activity is retained as a valid data point. Abrupt changes may trigger systems dependent monitoring.

8.14.3.6.3 Trend Evaluation

Incoming water quality data are presently evaluated manually to identify trends. This evaluation takes place, along with the evaluation for outliers, as soon as practicable after new data are input to the computerized data base.

8.14.3.7 Auditing

General features of auditing program are presented in Section 8.14.2.6. Those elements unique to water quality data are discussed below.

Environmental engineers from the Environmental Services Department in Grand Junction make periodic audits of field sampling and laboratory procedures. An auditing schedule identifies the procedures to be checked. The auditors attempt to identify deviations from the quality assurance procedures that embrace sampling and measurement. This includes sampling procedures, calibration, documentation, and so forth. Audit reports are prepared and forwarded to the environmental engineer in charge of audit and compliance activites.

8.14.4 Noise

The environmental noise monitoring program (which is distinct from the occupational health monitoring program) at the C-b Tract consists of continuous 24-hour readings every sixth day at two stations in the proposed Development Monitoring phase. One station is located at the northern boundary of the Tract; the other is near the guard gate.

The modest manpower requirements and the ease of instrument operation preclude the need for lengthy formal training. When there is a change of personnel, the new operator will learn the monitoring procedures from an experienced operator or environmental engineer from the Environmental Services Department.

Data from the sound level meters are recorded on strip charts which, after review by the operator, are forwarded to DP for data reduction and verification. The noise data are not voluminous and therefore are stored on manually prepared tables.

8.14 Quality Assurance

The sound level meters have been calibrated to the temperature and altitude conditions at the Tract. The meters also have calibrators that produce a test signal of known frequency and volume. The operator uses this signal to calibrate the meters before and after every period of use; recorders also receive regular calibration. See Section 8.7 for further details.

8.14.5 Biology

8.14.5.1 Quality Assurance Handbook

To facilitate a systematic and consistent application of data gathering techniques, a quality assurance handbook will be issued in 1984. The handbook will address the following:

- Monitoring procedures;
- Procedures to operate and maintain equipment;
- Methods to screen data for quality;
- Procedures for corrective action (e.g., resampling);
- Reporting.

8.14.5.2 Training

The monitoring of many biological parameters relies more on experienced observation than special instrumentation. As a consequence, CB has assembled a monitoring team that is highly qualified to monitor the range of biological parameters of interest. CB personnel are technically qualified and most have long-term familiarity with the site. New staff members are given extensive field training by CB staff and consultants.

Much of the biological data is analyzed by consultants. These consultants keep CB informed about new analytical and monitoring techniques and provide training as required.

8.14 Quality Assurance

8.14.5.3 Sample Collection and Measurement

There are several classes of biological and related conditions that are monitored on the site. Terrestrial fauna and avifauna are monitored to determine species, abundance, and selected other characteristics. Much of the data is collected by direct observation and inspection of animals, tracks, and pellet groups. The quality of the data collected is assured by careful observations, well prescribed monitoring procedures, thorough data log documentation, and comparison of data with historic trends. After data are collected, they are compared to baseline information to identify deviations from the norm and possible collection procedural problems. The decision to obtain additional sampling or rechecking historical data is based on professional judgement.

Quality assurance for measurement of the structure, composition, productivity, and utilization of terrestrial vegetation is carried out in much the same manner. An added tool is used for verifying biomass estimates as follows. Biomass is estimated through observation in four transects and then measured by clipping and weighing the fifth. The quantified measure gives the observer a means to calibrate his subsequent visual estimates. Furthermore, measurements are made twice.

Aquatic ecology is monitored through the measurements of benthos and periphyton. Quality assurance for sampling and laboratory measurement is essentially the same as that described in Section 8.14.3, Water. Quality assurance procedures for microclimate monitoring of air and soil temperature, precipitation, snow depth, and moisture are similar to those used for monitoring both air and water.

8.14 Quality Assurance

8.14.6 Subsidence

Subsidence monitoring is scheduled to commence in 1985. There will be three forms of monitoring: (1) underground surveys of horizontal and vertical locations, (2) above ground surveys of horizontal and vertical locations, and (3) tiltmeters. The underground surveys will be conducted annually; above ground they may be conducted as frequently as monthly in active areas. Tiltmeters will provide continuous readings.

The surveys will be conducted by qualified survey crews using standard survey techniques (e.g., survey closure and error analysis) and optical equipment. Likewise the tiltmeters will be installed, maintained, and calibrated according to manufacturers' specifications and standard scientific practice.

Data will be processed and monitoring procedures will be audited in the manner described in Sections 8.14.2.5 and 8.14.2.6, respectively.

8.14.7 Tract Imagery

Several types of imagery monitor conditions at the C-b Tract in the Development Monitoring phase. These include ground photography, aerial photography, and Landsat multi-spectral imagery. Each type is useful for detecting change in vegetation conditions. Additionally, aerial photography possibly can be used to detect subsidence.

Conventional photography is analyzed qualitatively. Consequently, normal care in acquiring photographs coupled with calibrations via step color or contrast wedges are sufficient quality assurance.

In 1980, CB undertook a test program to use Landsat data to quantify changes in general vegetative conditions. Quality assurance occurred at several points

during the development of the data base. Ground receiving stations process the incoming signals from the Landsat satellites and produce computer compatible tapes (CCT) for each image. The CCT digital data are reported and scaled so that the image produced by the computer is the same scale as a 1:24,000 topographic map.

To provide several data points for data registration, CB used data from four Landsat passes between June and August, 1980. Recognizable surface features were used to register the Landsat images with the map. Because of the variety of the terrain there is reasonable confidence that maps were registered (i.e., "accurate") to within one picture element (pixel), which for Landsats 2 and 3 is nominally 80 x 80 meters square (approximately one acre). In 1985 the Landsat's Thematic Mapper with 30 x 30 meter improved ground resolution is expected to become operational.

To equate Landsat data with actual biomass (vegetation index) a ground truth program was conducted. This program is described in Section 8.4. The Landsat technique was found to have promise as a monitoring tool.

8.14.8 Operations

8.14.8.1 Introduction

Monitoring of mine/process operations is performed to effect control, to assure safety and to provide records and reports.

8.14.8.2 Control and Recording Equipment

Quality assurance of monitoring equipment and methods for those functions that are needed solely to effect control will be obtained by sound engineering practices and vendor/equipment evaluation and selection. The same method will be used to assure the quality of equipment that provide records and reports, except that those items directly involved in lease/royalty value determinations will be selected from vendors that supply similar equipment to the oil/gas industry and will be certified as accurate.

8.14.8.3 Safety Equipment

Equipment and methods used to monitor mine and worker area environments for air quality or fire potential will be selected from those approved by MSHA, Factory Mutual, or Underwriters Laborabories as appropriate. An extensive study will be conducted to determine and evaluate the kind (make, model and type) of equipment that is presently being used in similar applications. The equipment selected will be that which is determined to be the most reliable. In some cases, redundant equipment may be used. After installation, periodic tests and calibration will assure continued reliability.

8.0 DEVELOPMENT MONITORING PLAN

8.15 Data Management and Reporting

TABLE OF CONTENTS

LIST OF FIGURES

8.15 Data Management and Reporting

8.15.1 Introduction and Scope

The purpose of this section is to identify the steps from environmental, health and safety sampling to the reporting of information obtained from statistical and visual analyses of the data. The goal is to ensure that each of these steps is performed at a high level of competency resulting in high quality, valid reporting.

8.15.2 Data Control

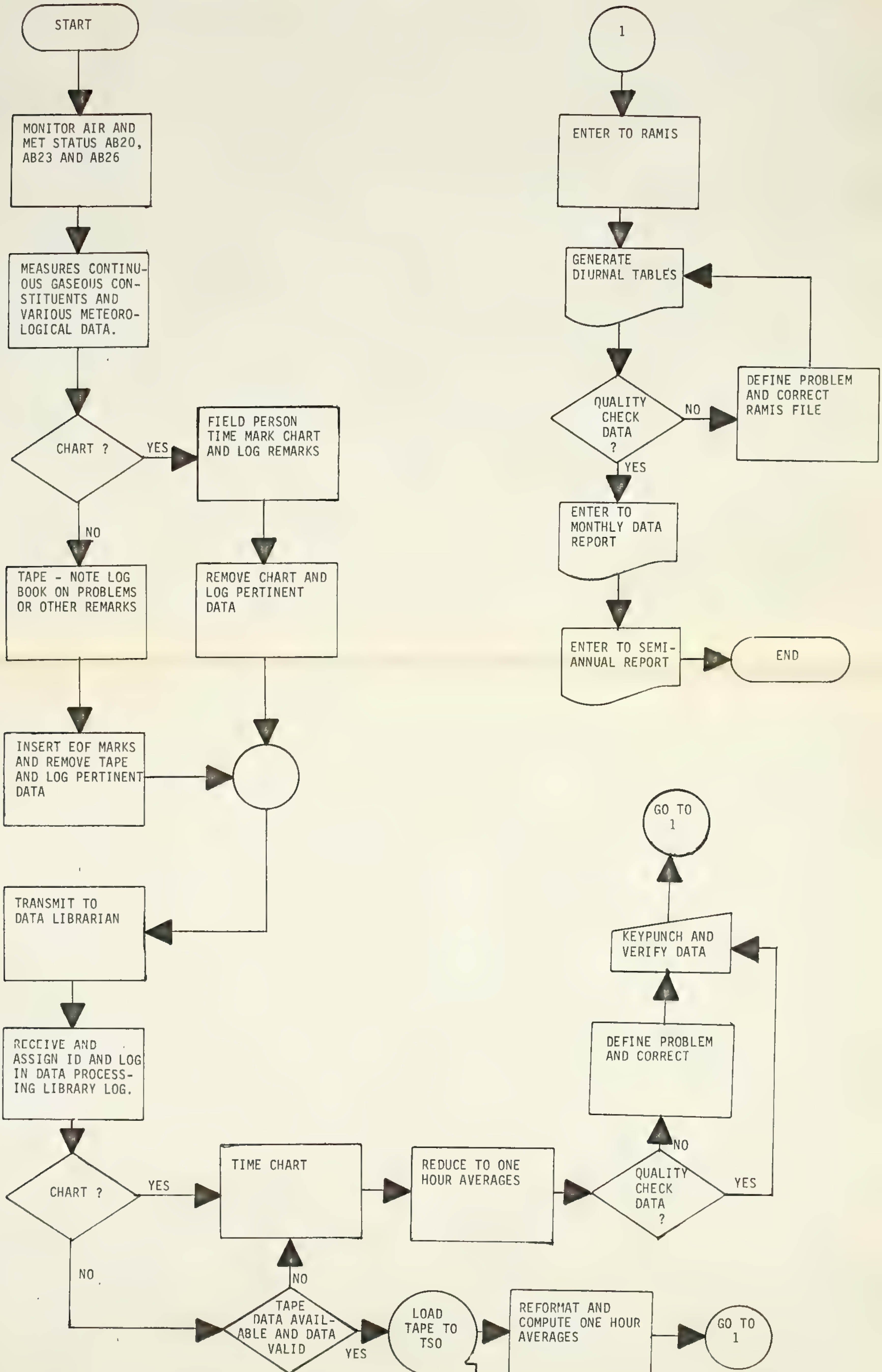
8.15.2.1 Data Flow

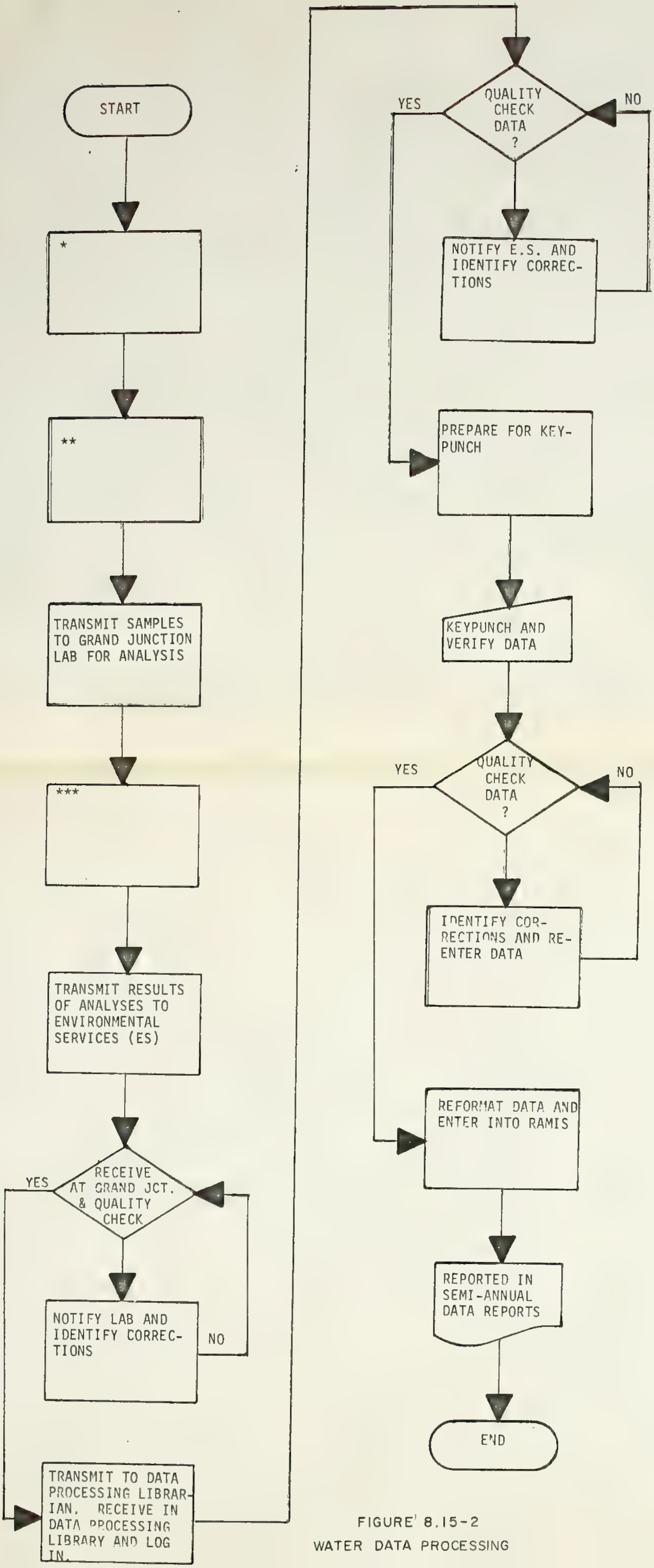
Field personnel collect and deliver data to the data librarian in the Data Processing Section. It is then logged into a notebook and assigned a library code. Then data are reduced manually and/or prepared for data entry to the computerized data base. Data are then available for retrieval for analyses and reporting. The data base provides for permanent storage and archival.

Environmental data are processed from several forms i.e.: magnetic tape, laboratory analysis data sheets, and handwritten field data sheets. Flow charts of air, water and biological data are displayed in Figures 8.15-1 through 8.15-3.

Logged-in data are scanned for possible errors. After the data are reduced they are quality checked for errors during the reduction process. The data are checked again before they are prepared for data entry. The data are then entered into the data base and verified. Quality Assurance is discussed further in Section 8.14.

FIGURE 8.15-1 AIR QUALITY AND METEOROLOGICAL-MAGNETIC TAPE AND MULTIPOINT STRIP CHART PROCESSING



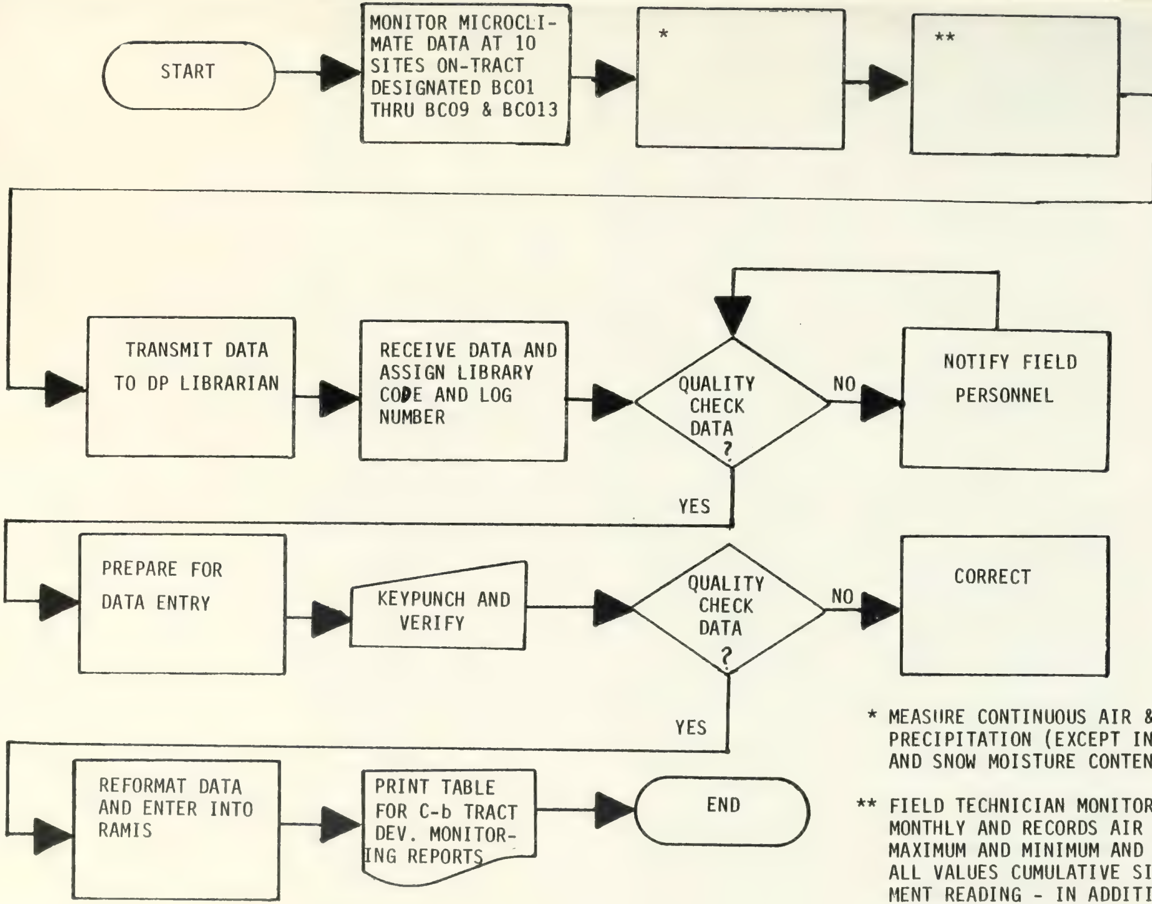


*ANALYSIS OF WATER SAMPLES FROM ALL (OOSI SAMPLED) SOURCES, (WELLS, SPRINGS AND SEEPS, STREAMS, SHAFTS, PONDS, SUMPS)

**DISCRETE SAMPLING OF STATIONS MONITORED ON SCHEDULED BASIS. THIS WATER SAMPLE CODE IDENTIFIES THE PROJECT SAMPLING SITE 4-DIGIT COMPUTER CODE, JULIAN DATE, SAMPLE NO. PURPOSE OF SAMPLE AND SET OF PARAMETERS FOR ANALYSIS.

***RECEIVE SAMPLES IN LAB AND PERFORM ANALYSES WITHIN TWO WEEKS OR ONE MONTH OF SAMPLE DATE (DEPENDING ON SAMPLE PURPOSE)

FIGURE 8.15-2
WATER DATA PROCESSING



* MEASURE CONTINUOUS AIR & SURFACE TEMPERATURE, PRECIPITATION (EXCEPT IN WINTER), SNOW DEPTH AND SNOW MOISTURE CONTENT (WINTER ONLY).

** FIELD TECHNICIAN MONITORS INSTRUMENTS TWICE MONTHLY AND RECORDS AIR AND SURFACE TEMPERATURE MAXIMUM AND MINIMUM AND TOTAL PRECIPITATION - ALL VALUES CUMULATIVE SINCE THE LAST INSTRUMENT READING - IN ADDITION TO THE DATE AND TECHNICIANS INITIALS. DURING THE WINTER SNOW DEPTH AND SNOW MOISTURE MEASUREMENTS ARE TAKEN.

FIGURE 8.15-3

MICROCLIMATE DATA PROCESSING

8.15.2.2 Station Codes

Station codes provide a means in the computer to identify the specific station by type and location and to allow grouping and retrieval of stations of common characteristics. Four digit alpha-numeric computer codes are assigned. The first character of the code designates the type of sample. The last two characters identify the designation or location of the station. The first two digits are alpha characters and the last two are numeric.

8.15.2.3 Data Library

The purpose of the data library is to log and monitor processing status of all data received. After the data have been logged, each site for a specified data type is assigned a library code. The first character of the code designates a station for a specific data type. The middle characters of the library code are an abbreviated description of data monitored at a station or location. The last character of the code is a log number.

8.15.3 Data Bases

8.15.3.1 Rapid Access Management Information (RAMIS II)

RAMIS II is the principle data base management system used to store the CB environmental data. This software is flexible with other library systems and permits users to store, manipulate, retrieve, and display large quantities of

data. It can be invoked either through English-like nonprocedural languages or traditional procedural languages such as Cobol, Fortran, or PL/1.

All environmental data are stored in several files within RAMIS. Two files contain air quality and meteorological data; six files contain water data. One file contains water level and flow, others contain water quality, biology, noise, consumables, water usage, geology, health, safety, and socioeconomic data pertaining to the C-b Tract.

8.15.3.2 Water Storage and Retrieval System (WATSTORE)

WATSTORE is a governmental data base managed by the Water Resources Division of the United States Geological Survey (USGS) in Reston, Virginia. It is used primarily as a data retrieval system. Flow and water quality data for stream gauging stations in the Piceance Basin are sampled by the USGS and stored in WATSTORE. Data are then retrieved by CB via computer communications from WATSTORE to an in-house system where analyses are performed.

8.15.4 Data Analyses

8.15.4.1 Statistical Analyses

The Statistical Analysis System (SAS) is a software package containing statistical procedures which can be linked with RAMIS II Data Base System for analyzing environmental data. Two types of statistical analyses available are designated as inferential or descriptive.

8.15.4.1.1 Inferential Statistical Analyses

Types of inferential statistical analyses include time-series analyses, correlation and regression, parametric and nonparametric statistical analyses, and special statistical analyses applicable to particular studies. All are recognized and proven statistical techniques.

8.15.4.1.2 Descriptive Statistical Analyses

Descriptive statistics are used with professional judgement to determine, if and to what extent the environment has been impacted by oil shale development. No hypothesis are tested or inferences made using descriptive statistics. Descriptive parameters may include the mean, mode, median, variance, and range, and are used when data are inadequate for inferential analyses. Charts, histograms and plots are be used to provide visual and comparative analyses for professional interpretation.

8.15.5 Data Plots

8.15.5.1 Plotting Software Packages

Three graphics software packages are available:

(1) Statistical Analysis System (SAS) Graphics --

SAS is used for producing graphical displays and plots, and three dimensional isometric plots. It is compatible with both the line printer and CALCOMP plotter.

8.15 Data Management and Reporting

(2) Contour Plotting System - 1 (CPS1) --

Contour and three dimensional isometric plots are obtained from the CPS-1 system. All plotting is done on the CALCOMP plotter.

(3) California Computer Products (CALCOMP) --

The CALCOMP Software package may be employed for either two- or three-dimensional plots. A typical application is the plotting of meteorological wind roses (i.e., a polar plot of wind speed magnitude by direction).

8.15.5.2 Environmental Graphic Displays

Types of environmental graphic displays are described below:

(1) Time Series Plots --

Hydrological, water quality, air quality and meteorological data are plotted over time to visually depict possible trends, establish a pictorial history of the data and/or to determine variations over time between stations.

(2) Correlation Plots

Correlation plots to show relationships between independent random variables, such as correlation of precipitation and flow.

(3) Contour Plots --

Contour plots include precipitation isohyets and piezometric surface maps of groundwater elevations.

8.0 DEVELOPMENT MONITORING PLAN

8.15 Data Management and Reporting

8.15.6 Data Reports

8.15.6.1 Monthly Data Reports

Monthly air and water quality internal reports consist of tabulated monitoring variables. Air is monitored continuously. Water is sampled daily, weekly, monthly, quarterly or semi-annually depending on station and variable.

8.15.6.2 Semi-Annual Data Reports

Environmental and health and safety data are reported semi-annually to the OSPO in tabulated and graphical form. Environmental data include air, water, biology and noise. Mine gas sampling and accident frequency reports represent health and safety data.

8.15.6.3 Annual Report

The CB Annual Report is normally a multiple volume report. Volume 1 includes a summary of development activities, costs and environmental monitoring. Volume 2 is an indepth analysis for all areas of environmental concern. This report is provided to the OSPO as a condition of the Lease and is widely distributed to governmental agencies, industry and other groups. This report includes inferential and descriptive statistical analyses as derived from mathematical models.

Future annual and data reports will incorporate SFC reporting requirements.

8.0 DEVELOPMENT MONITORING PLAN

References

8.0 DEVELOPMENT MONITORING PLAN

References

CB Air Monitoring Quality Assurance Manual and Standard Operating Procedures (1981).

CB (1981): Quality Assurance Program for Hydrology. Feb., 1981.

CB Oil Shale Venture (1980): Water Analysis Quality Control Procedures for CB Laboratory, March, 1980.

CB Shale Oil Project (1976): Annual Summary and Trends Report. First Year Environmental Baseline Program. Feb. 25, 1976.

CB Shale Oil Project, CB Annual Reports.
1978 - Vols. 1 and 2, 2 App. April 20, 1979
1979 - Vols. 1 and 2, App. April 30, 1980
1980 - Vols. 1 and 2, App. April 30, 1981
1981 - Vols. 1 and 2, App. April 30, 1982
1982 - One Volume. April 30, 1983

CB Shale Oil Project. Data Reports Submitted to the Oil Shale Projects Office.

Quarterly Data Report #1	January 14, 1975
Quarterly Data Report #2	April 15, 1975
Quarterly Data Report #3	July 15, 1975
Quarterly Data Report #4	October 15, 1975
Quarterly Data Report #5	January 15, 1976
Quarterly Data Report #6	April 15, 1976
Quarterly Data Report #7	July 15, 1976
Quarterly Data Report #8	October 15, 1976
Quarterly Data Report #9	January 15, 1977
Interim Monitoring Report	October 17, 1977
Interim Monitoring Report, Supplemental	December 16, 1977
Interim Monitoring Report	May 15, 1978

References

CB Shale Oil Project. <u>Data Reports</u> (Continued)

Development Monitoring Report #1	January 15, 1979
Development Monitoring Report #2	July 15, 1979
Development Monitoring Report #3	January 15, 1980
Development Monitoring Report #4	July 15, 1980
Development Monitoring Report #5	January 15, 1981
Development Monitoring Report #6	July 15, 1981
Development Monitoring Report #7	January 15, 1982
Environmental Monitoring Report	July 15, 1982
Environmental Monitoring Report	January 15, 1983
Environmental Monitoring Report	July 15, 1983

CB Shale Oil Project (1976): <u>Detailed Development Plan and Related Materials</u>. Oil Shale Tract C-b. Ashland Oil, Inc. and Shell Oil Co., Operator. February, 1976.
Volume I
Volume II

CB Shale Oil Project (1979): <u>Development Monitoring Program for Oil Shale Tract C-b</u>, Occidental Oil Shale, Inc., Operator. February 23, 1979.

CB Shale Oil Project, <u>Quarterly Summary Reports</u>.

Summary Report #1, (thru November 30, 1974)
Summary Report #2, (thru February 28, 1975)
Summary Report #3, (thru May 31, 1975)
Summary Report #4, (thru August 31, 1975)
Summary Report #5, (thru November 30, 1975)
Summary Report #6, (thru February 29, 1976)
Summary Report #7, (thru May 31, 1976)
Summary Report #8, (thru August 31, 1976)

References

CB Shale Oil Venture (1977): Environmental Baseline Program Final Report. Ashland Oil, Inc. and Occidental Oil Shale, Inc., Operator.

Executive Summary. 57 pp.
Vol. 1 Regional and Temporal Setting. 221 pp.
Vol. 2 Hydrology. 329 pp.
Vol. 3 Meteorology, Air Quality and Noise. 508 pp.
Vol. 4 Ecology. 457 pp.
Vol. 4 A & B Ecology Appendices, A & B. 509 pp.
Vol. 5 System Interrelationships. 249 pp.
Vol. 5 System Interrelationships, Appendix F. User's Reference Diagrams. The Unpaged

CB Shale Oil Venture (1974): Federal Oil Shale Prototype Leasing Program, Tract C-b Supplemental Exploration Plan. Ashland Oil, Inc., Atlantic Richfield Co., Oil Shale Corp., and Shell Oil Co. May 15, 1974.

CB Shale Oil Venture (1977): Modifications to Detailed Development Plan, Oil Shale Tract C-b. Submitted by Ashland Oil, Inc., Lessee, and Occidental Oil Shale, Inc., Operator, February, 1977.

CB Shale Oil Venture (1974): Preliminary Development Plan for Colorado Tract C-b. Ashland Oil, Inc., Atlantic Richfield Co., The Oil Shale Corp., and Shell Co., March 6, 1974.

Cairns, J., Jr. and K. L. Dickson (eds.) (1973): "Biological Methods for the Assessment of Water Quality." American Society of Testing and Materials Special Technical Publication S28:1-256.

Cholnoky, B. J. (1968): Die o Kologie der Diatomeen in Binnengewassern. J. Cramer, Lehre, Germany. 699 pp.

Cochran, W. G. and G. M. Cox (1957): Experimental Designs. 2nd ed. John Wiley & Sons, Inc., New York. 617 pp.

enes

t, J. M. (1977): Some Methods for the Statistical Analysis of Samples of tic Invertebrates. Freshwater Biological Associates. Scientific ication No. 25. 156 pp.

n J. T. (1977): "Population Densities of Birds Derived from Transect ut." Auk 88: 323-342.

1976, 1977a): Quality Assurance Handbook for Air Pollution Measurement stems, Vol. 1, Principles, March 1976; Vol. II, Ambient Air Specific Methods, y 1977; Vol. III, Stationary Source Specific Methods, August 1977.

(1979a): Methods for Chemical Analysis of Water and Wastes.

(1979b): Handbook for Quality Control in Water and Wastewater Laboratories

tchinson, G. E. (1975): A Treatise on Limnology. Vol. III. Limnological Botany. John Wiley and Sons, New York. 660 pp.

ynes, H. R. N. (1970): The Ecology of Running Waters. University of Toronto Press. Suffolk, Eng. 555 pp.

Kolkowitz, R. and M. Marsson. (1909): "Ecology of Animal Saprobia." Int. Rev. Hydrobiology and Hydrogeography. 2:126-153.

Lloyd, M. and R. J. Ghelardi. (1964): "A Table for Calculating the 'Equitability' Component of Species Diversity." Journal of Animal Ecology. 33:217-255.

Lowe, R. L. (1974): Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. U. S. Environmental Protection Agency. Environmental Monitoring Series. EPA-670 4-74-005. 334 pp.

Margalef, R. (1967): Information Theory in Ecology (Translated by W. Hill), "General System." 3:36-71.

References

Ott, L. (1977): An Introduction to Statistical Methods and Data Analysis. Duxbury Press, North Scituate, Mass. 730 pp.

Patrick, R. (1977): "Ecology of Fresh Water Diatoms - Diatom Communities." The Biology of Diatoms. D. Werner (ed.). Univ. of Calif. Press. Berkeley, California. 498 pp.

Pielou, E. C. (1975): Ecological Diversity. John Wiley & Sons, Inc., U.S. and Canada.

Snedecor, G. W. and W. G. Cochran. (1967): Statistical Methods. Iowa State Univ. Press, Ames, Iowa. 593 pp.

Weber, C. I. (1973): Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. U. S. Environmental Protection Agency. Environmental Monitoring Series. EPA-670/4-73-001.

Whitton, B. A. (ed) (1975): River Ecology. Univ. of California Press, Berkeley, California. 725 pp.

9.0 DOCUMENT CONTROL

TABLE OF CONTENTS

LIST OF TABLES

9.0 DOCUMENT CONTROL

As described in Section 1.6, a document control system is used to keep the DDP current and self-contained and to help the reader track changes to the DDP. Table 9.0-1 contains a list of 1) project changes that have been requested by CB or supporting information in regard to these changes requested by the OSPO, 2) responses to and approvals of those requests, and 3) the location in the DDP of textual changes resulting from project changes. The request and response numbers are used by CB for internal control.

Each page that is changed is marked with a revision date, and a master list of revisions is included here (Table 9.0-2). The appropriate portions of this table are repeated at the beginning of each volume.

A revised version of Tables 9.0-1 and 2 will be reissued periodically to reflect textual changes to the DDP.

TABLE 9.0-1

Chronological Synopsis of DDP Updates

CHANGE REQUEST				RESPONSE/APPROVAL				DDP REVISION	
REQ* NO.	DATE	SOURCE+	NATURE OF REQUEST	RES.* NO.	DATE	SOURCE+	COMMENT/CONDITIONS	REV. DATE	DDP PAGE

* Assigned by CB

\+ Author/signitor and affiliation (i.e., OSPO or CB)

TABLE 9.0-2

DDP Revisions by Section

DDP OUTLINE	Revisions PAGE NO.	DATE
1.0 INTRODUCTION		
1.1 Introduction		
1.2 Lease Program and History		
1.3 Lease Provisions and Compliance		
1.4		
etc.		

TABLE OF CONTENTS

GLOSSARY

"A" Groove - approximate upper boundary to the Mahogany Zone.

Anticline - an arch of stratified rock in which the layers bend downward in opposite directions from the crest.

Aquiclude - a body of relatively impermeable rock that is capable of absorbing water slowly but functions as an upper or lower boundary of an aquifer and does not transmit ground water rapidly enough to supply a well or spring.

Aquitard - a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed.

"B" Groove - approximate lower boundary to the Mahogany Zone.

Basal - relating to, situated at, or forming the base.

Benching - a method of working a mine in steps or benches (blasting holes are drilled from the top and material is blasted into the void occupied by the previously blasted bench).

Blowdown - a reservoir used to capture process liquids, often used for emergencies.

Brattice - an often temporary partition used in a mine to control ventilation.

Calcareous - a. consisting of or containing calcium carbonate, b. growing on limestone or in soil impregnated with lime.

Calcine - to heat to a high temperature but without fusing in order to effect useful changes (as oxidation or pulverizing).

Channery - thin, flat coarse fragments of limestone, sandstone, or schist, having diameters as large as 6 in. (150 mm).

Colluvium - rock detritus and soil accumulated at the foot of a slope.

Cone of Influence (depression) - the cone shaped gradation of water level in an aquifer.

Depocenter - an area or site of maximum deposition, the thickest part of any specified stratigraphic unit in a depositional basin.

Dessicant - a drying agent.

Detritus - loose material that results directly from rock disintigration especially when composed of rock fragments.

Dip - the angle that a stratum or similar geologic feature makes with a horizontal plane.

Drift - a. a nearly horizontal mine passageway driven on or parallel to the course of a vein or rock stratum, b. a small crosscut in a mine connecting two larger tunnels.

Emetic - an agent that induces vomiting.

Epeirogency - the deformation of the earth's crust by which the broader features of relief are produced.

Feral - not domestically cultivated.

Grabben - a depressed segment of the earth's crust bounded on at least two sides by faults.

Grizzly - a rugged screen for rough sizing at a comparatively large size (e.g., 6 in.).

Heading - drift

Hydrotreat - to remove heterostems (e.g., oxygen, nitrogen, sulfur, and metals) by reaction with hydrogen

Incised - having a margin that is deeply and sharply notched.

Joint - a surface of actual or potential fracture or parting in a rock, without displacement.

Joint Set - a regional pattern of groups of parallel joints.

Jumbo - a drill carriage in which several drills are mounted.

Knockout Drum - a vessel used to capture liquids from a gas stream.

Lenticular - having the shape of a double-convex lens.

Lithology - the character of a rock formation.

Loft - the vertical height traveled by a cage in a shaft.

Mahogany Zone - 100 foot (more or less) zone of the richest oil shale.

Mesic - moderately moist

Montane - of, pertaining to, or inhabiting cool upland slopes below the timber line, characterized by the dominance of evergreen trees.

Muck - material removed in the process of excavating or mining.

Phreatophyte - tree or bush whose roots are generally embedded in the water table or one that generally lives near water sources.

Piezometric - pertains to (surfaces of) equal pressure.

Pig - a metal, football shaped object with surrounding gaskets used as a divider between different liquids in a pipeline.

Plenum - an enclosed space in which the pressure of the air is greater than that of the outside atmosphere.

Quadrat - a usually rectangular plot used for ecological studies.

Raise - an upward grade.

Residium - a residual product.

Room and Pillar Mining - a system of mining in which ore is mined in rooms separated by ribs or pillars.

Rubblization - the act of converting (blasting) the oil shale deposit into rough irregular rock (rubble) in place.

Ruminants - of or relating to a suborder of even-toed hoofed mammals (as sheep and deer).

Skip - a large steel hoisting bucket used in vertical or inclined shafts for hoisting material.

Slabbing - a. to divide or form into slabs, b. to remove an outer slab.

Slicing - removal of a horizontal layer from a massive ore body (the floor of the slice will become the top of the bench in CB operations).

Sloughing - to crumble slowly and fall away.

Stacker - a conveyor adapted to piling or stacking bulk materials.

Stoichiometry - a branch of science that deals with the application of the laws of definite proportions and of the conservation of matter and energy to chemical activity.

Sweeten - to remove sulfur.

Syncline - a trough of stratified rock in which the beds dip toward each other from either side.

Synoptic - relating to or displaying atmospheric and weather conditions as they exist simultaneously over a broad area.

ACRONYMS AND ABBREVIATIONS

A

AA	attainment area
ACFM	actual cubic feet per minute
ADT	average daily traffic
AF	acre-feet
AGR	Aboveground Retort
AMC	American Mining Congress
ANFO	ammonium nitrate and fuel oil
APCA	Air Pollution Control Association
APEN	Air Pollution Emission Notice
API	American Petroleum Institute
APRAC	Air Pollution Research Advisory Committee
AQCR	Air Quality Control Region
AQRV	Air Quality Related Values
ARCO	Atlantic Richfield Company
ASTM	American Society for Testing Materials
AUM	animal unit month
AWT	advanced wastewater treatment

B

BACT	Best Available Control Technology
BACTEA	Best Available Control Technology Economically Achievable
BADCT	Best Available Demonstrated Control Technology
BAP	Benzo (α) Pyrene
BART	Best Available Retrofit Technology
BAT	Best Available Technology
Bbls	barrels
BFW	boiler feed water
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
BPCD	barrels per calendar day
BPSD	barrels per stream day
BTU	British thermal unit

C

CAA	Clean Air Act
CAAA	Clean Air Act Amendment
CAPCD	Colorado Air Pollution Control Division
CAQCA	Colorado Air Quality Control Act
CAQCC	Colorado Air Quality Control Commission
CAQCD	Colorado Air Quality Control Division
CASAC	Clean Air Scientific Advisory Committee
CB	Cathedral Bluffs Shale Oil Company
CBSOC	Cathedral Bluffs Shale Oil Company
CC	Cleanup Coordinator
CD	calendar day
CDM	Climatological Dispersion Model
CEC	cation exchange rate
CEI	Consortium of Energy Impacts
CEQ	Council on Environmental Quality
CFM	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
CITF	Colorado Impact Task Force
cm	centimeter
CMA	Chemical Manufacturers Association
CMLRB	Colorado Mined Land Reclamation Board
CO	carbon monoxide or consent order
Co.	County
CO_2	carbon dioxide
COD	chemical oxygen demand
COE	Corps of Engineers
CRSTER	Single Source Terrain Model
CWA	Clean Water Act
CWAA	Clean Water Act Amendments
CWQCA	Colorado Water Quality Control Act
CWQCC	Colorado Water Quality Control Division

D

dBA	decibels (A-weighted)
DC	Document Coordinator
DDP	Detailed Development Plan
DNR	Department of Natural Resources
DO	dissolved oxygen
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
DOW	Department of Wildlife
DP	Data Processing

E

E	east
EA	Environmental Assessment
ECe	electrical conductivity
ED	electrodialysis
EDF	Environmental Defense Fund
EIS	environmental impact statement
EMT	emergency medical technician
EPA	Environmental Protection Agency
EPC	Environmental Protection Coordinator
ES	Exhaust Shaft
ESP	electrostatic precipitator
ESP	exchangable sodium percentage

F

FDA	Federal Drug Administration
FGD	flue gas desulfurization
FLPMA	Federal Land Policy and Management Act
FOIA	Freedom of Information Act
ft	foot, feet
FWPCA	Federal Water Pollution Control Act

G	
gal	gallon
GAO	General Accounting Office
GEP	good engineering practice
GLC	ground level concentration
gm	gram
GNP	gross national product
gpm	gallons per minute
GPD	gallons per day
gpt	gallons per ton
H	
HB	House Bill
HEW	Health, Education and Welfare
HIGG	hot inert gas generator
hp	horsepower
H_2S	hydrogen sulfide
HT	hydrotreated
HW	hazardous waste
I	
IP	inhalable particulates
in.	inch
ISC	Industrial Source Complex Model
ITC	Interagency Testing Committee (EPA - TSCA)
J	
JRP	Joint Review Process
K	
km	kilometer
kw	kilowatt
kv	kilovolt
kva	kilovolt ampere

L	
LAER	Lowest Achievable Emission Rate
lb	pound
LBL	Lawrence Berkeley Laboratory
LC50	lethal concentration - 50%
LD50	lethal dose - 50%
LHD	load haul dump (vehicle)
LIDAR	light detection and ranging
LNG	liquified natural gas
LPC	Lower Parachute Creek
LPG	liquified petroleum gas
M	
M	thousand
m	meter
mb	millibars
MB/D	thousand barrels per day
meq	milliequivalent
mgd	million gallons per day
mi	mile
MIS	modified in situ
mg/l	milligrams per liter
ml	milliliter
MLR	mined land reclamation
MLRB	Mined Land Reclamation Board
mm	millimeter
MM	million
MMBPD	million barrels per day
MMHOS/cc	Micro-mhos per cubic centimeter
MOU	memo of understanding
MPTER	Multiple Point Terrain Model
MSHA	Mine Safety and Health Administration
msl	(with respect to) mean sea level
MSS	multispectral sensor
mva	megavolt ampere
mw	megawatt

N

N	north
NAA	non-attainment area
NAAQS	National Ambient Air Quality Standards
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NASN	National Air Sampling Network
NCA	National Coal Association
NE	northeast
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute of Occupational Safety and Health
NMHC	non-methane hydrocarbons
NOAA	National Oceanic Atmospheric Administration
NO	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Response Center (USCG) or Nuclear Regulatory Center
NRCC	National Resources Conservation Council
NRDC	Natural Resources Defense Council
NSCP	National Spill Contingency Plan
NSPS	New Source Performance Standards
NSR	New Source Review
NW	northwest
NWF	National Wildlife Federation

O

O_3	ozone
OAQPS	Office of Air Quality Planning and Standards
OMB	Office of Management and Budget
OMSAPC	Office of Mobile Source Air Pollution Control (EPA)
OOSI	Occidental Oil Shale, Inc.

O (Cont'd)

OPTS	Office of Pesticides and Toxic Substances (EPA)
ORD	Office of Research and Development
OSEAP	Oil Shale Environmental Advisory Panel
OSHA	Occupational Safety and Health Act
OSM	Office of Surface Mining
OSPO	Oil Shale Projects Office
OSTF	Oil Shale Trust Fund
OTS	Office of Toxic Substances (EPA)
OUG	Oil Upgrader
OXY	Occidental Petroleum Corporation

P

PAH	polyaromatic hydrocarbons
PLS	pure live seed
PM	particulate matter
PMN	Premanufacture Notice
PNA	polynuclear aromatic
POM	polycyclic organic material
ppm	parts per million by weight
ppmv	parts per million by volume
PSA	pressure swing absorbtion
PSD	Prevention of Significant Deterioration
psig	pounds per square inch (gage)

R

RACT	Reasonably Available Control Technology
RARE	Roadless Area Review and Evaluation
RARE II	Roadless Area Review and Evaluation Program
RCRA	Resource Conservation and Recovery Act
RMOGA	Rocky Mountain Oil and Gas Association
RO	reverse osmosis
ROM	run-of-mine
ROW	right-of-way
R/P	room and pillar

S

S	south
SAROAD	Storage and Retrieval of Aerometric Data
SCFD	standard cubic foot per day
SCFH	standard cubic feet per hour
SCFM	standard cubic feet per minute
SCS	U. S. Soil Conservation Service
SD	stream day
SDWA	Safe Drinking Water Act
SE	southeast
SEC	Securities and Exchange Commission
Sec.	Section
sec	second
SFC	Synthetic Fuels Corporation
SH	superheated
SIP	State Implementation Plan
SMCRA	Surface Mining Control and Reclamation Act
SO_2	sulfur dioxide
SOP	standard operating procedures
SO_x	sulfur oxides
SPCC	Spill Prevention Control and Countermeasures
SPF	Surface Processing Facilities
sq.	square
SRC	Spill Response Coordinator
SSW	south-southwest
SW	southwest

T

TDS	total dissolved solids
TLV	threshold limit value
TM	thematic mapper
TOC	total organic carbon
TOSCO	The Oil Shale Company

T (Cont'd)

TPSD	tons per stream day
TPY	tons per year
TSCA	Toxic Substances Control Act
TSOC	Tenneco Shale Oil Company
TSP	total suspended particulates
TSS	total suspended solids

U

UG	underground
ug	microgram
ug/m^3	micrograms per cubic meter
UIC	Underground Injection Control
UPC	Upper Parachute Creek
UPS	uninterceptable power supply
USBM	United States Bureau of Mines
USCG	United States Coast Guard
USDA	United State Department of Agriculture
USDW	underground source of drinking water
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USPHS	United States Public Health Service

V

V/E	Ventilation/Escape
VOC	volatile organic compounds

W

W	west
WMA	Water Management Association
WOGA	Western Oil and Gas Association
WPCF	Water Pollution Control Federation
WQC	water quality criteria

W (Cont'd)

WQCD	Water Quality Control Division
WQS	Water Quality Standards
WREA	White River Electric Association
wt	weight

Y

yr	year

TABLE OF CONVERSION FACTORS

To Convert From	To	Multiply By
acres	ft^2	4.3560×10^4
acres	hectares	0.404687
acre-feet/yr	cfs	1.3803×10^{-3}
atmospheres	dynes/cm^2	1.01325×10^6
atmospheres	bars	1.01325
atmospheres	mm Hg	760
atmospheres	newtons/m^2	1.01325×10^5
atmospheres	lbs/ft^2	2116.32
barrel	gal	42
bars	atmospheres	0.98692
bars	mb	1000.00
bars	newtons/m^2	10^5
BTU (British Thermal Units)	gm cal	252.
cfm	liters/sec	0.4720
cfs	m^3/s	0.028317
cfs	acre-feet/yr	724.48
degrees Fahrenheit	degrees Kelvin	(°F-32)*(5/9) + 273
degrees Fahrenheit	degrees Centigrade	(°F-32)*(5/9)
degrees	radians	0.017453
feet	meters	0.3048
ft^2	meters	0.092903
ft^3/min	m^3/sec	0.000472
ft^3	gals	7.4805
ft^3	m^3	0.028317
gals	m^3	0.0037854
gals	liters	3.7853
gals/min	m^3/sec	0.00006309
gals/min	liters/sec	0.069088
grains	grams	0.064798918
grains	pounds	1.42857×10^{-4}
hectares	m^2	10^4
inches	cm	2.5400
$inch^3$	cm^3	16.3872
miles	kilometers	1.60935
mph	mps	0.44703
pounds	kilograms	0.45359
pounds/acre	kg/ha	1.12173
pounds/acre	grams/m^2	0.112173
pounds/hour	grams/sec	0.1260
pounds/$inch^2$	atmospheres	0.068046
pounds/$inch^2$	mb	68.947
radians	degrees	57.29578
rods	meters	5.0292
SCFM (Standard Cubic Ft/Min)	ACFM (Actual cubic ft./min)	$(^oK_a/^oK_s)$ $(P_s\ mb/P_a\ mb)$
ton (short)	kilograms	907.185
tons/yr	gm/sec	0.0287

CIRCULATION LIST

Shale Projects Office - 10 copies

Shale Environmental Advisory Panel - 40 copies

nternal Distribution - 30 copies

Form 1279–3
(June 1984)

BORROWER'S CARD

DATE LOANED	BORROWER	OFFIC

USDI – BLM